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Rothermel et al.

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(54) **ELECTRICAL CONNECTOR WITH PROGRAMMABLE LEAD FRAME**

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Related U.S. Application Data

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H01R 13/648 (2006.01)

(52) **U.S. Cl.** **439/607.07**; 439/507; 439/49

(58) **Field of Classification Search** 439/608, 439/507, 49, 510–512, 701, 607.07, 607.05, 439/607.06

See application file for complete search history.

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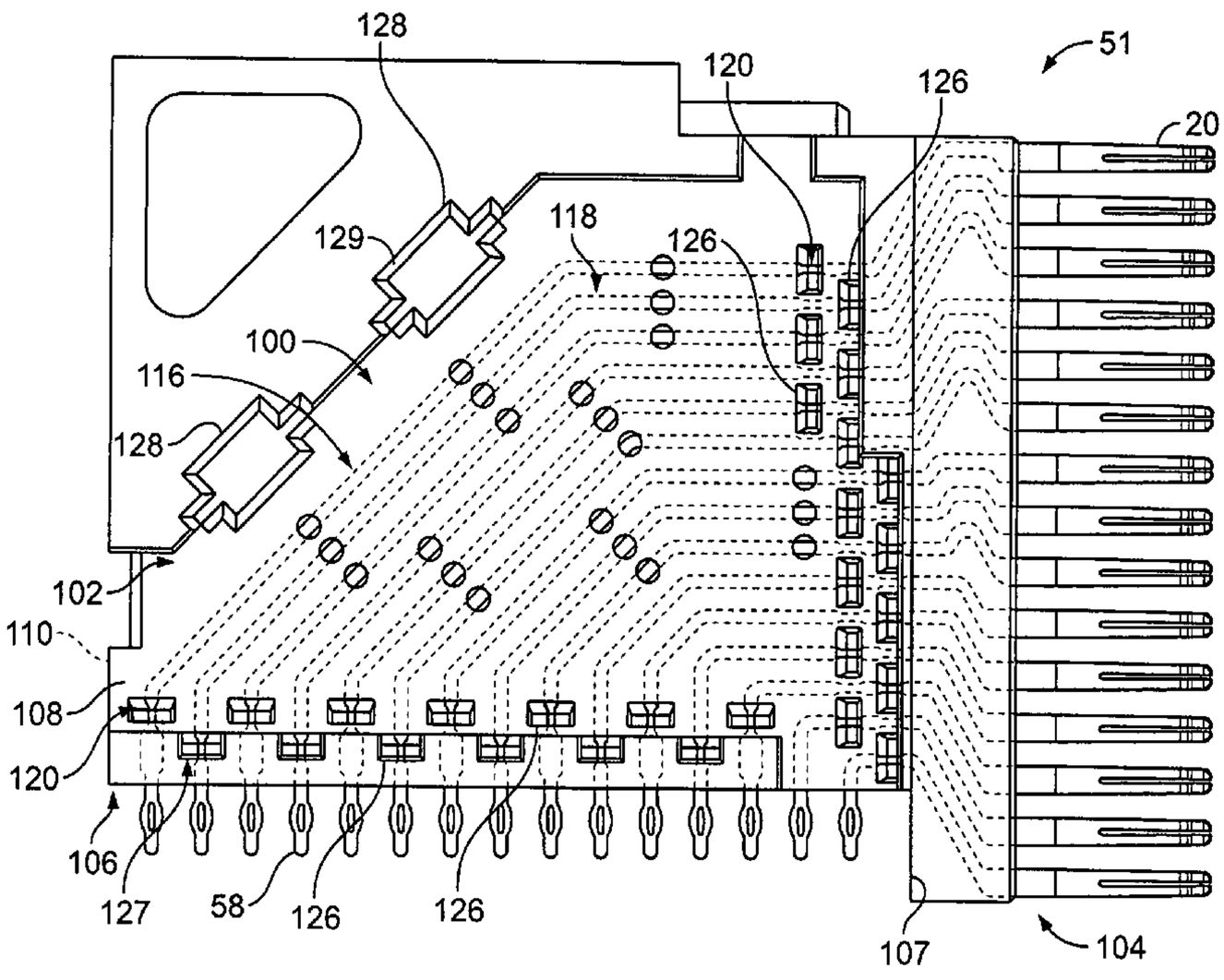
Primary Examiner—Gary F. Paumen

(57) **ABSTRACT**

A contact module assembly is provided for an electrical connector. The contact module assembly includes a lead frame having a plurality of terminals and a commoning member at least partially including an electrically conductive material. The commoning member has a plurality of tabs that are electrically connected to selected ones of the terminals, thereby electrically commoning the selected ones of the terminals. The commoning member can be configured with different patterns of the tabs to selectively configure the lead frame with different patterns of commoned terminals.

19 Claims, 17 Drawing Sheets



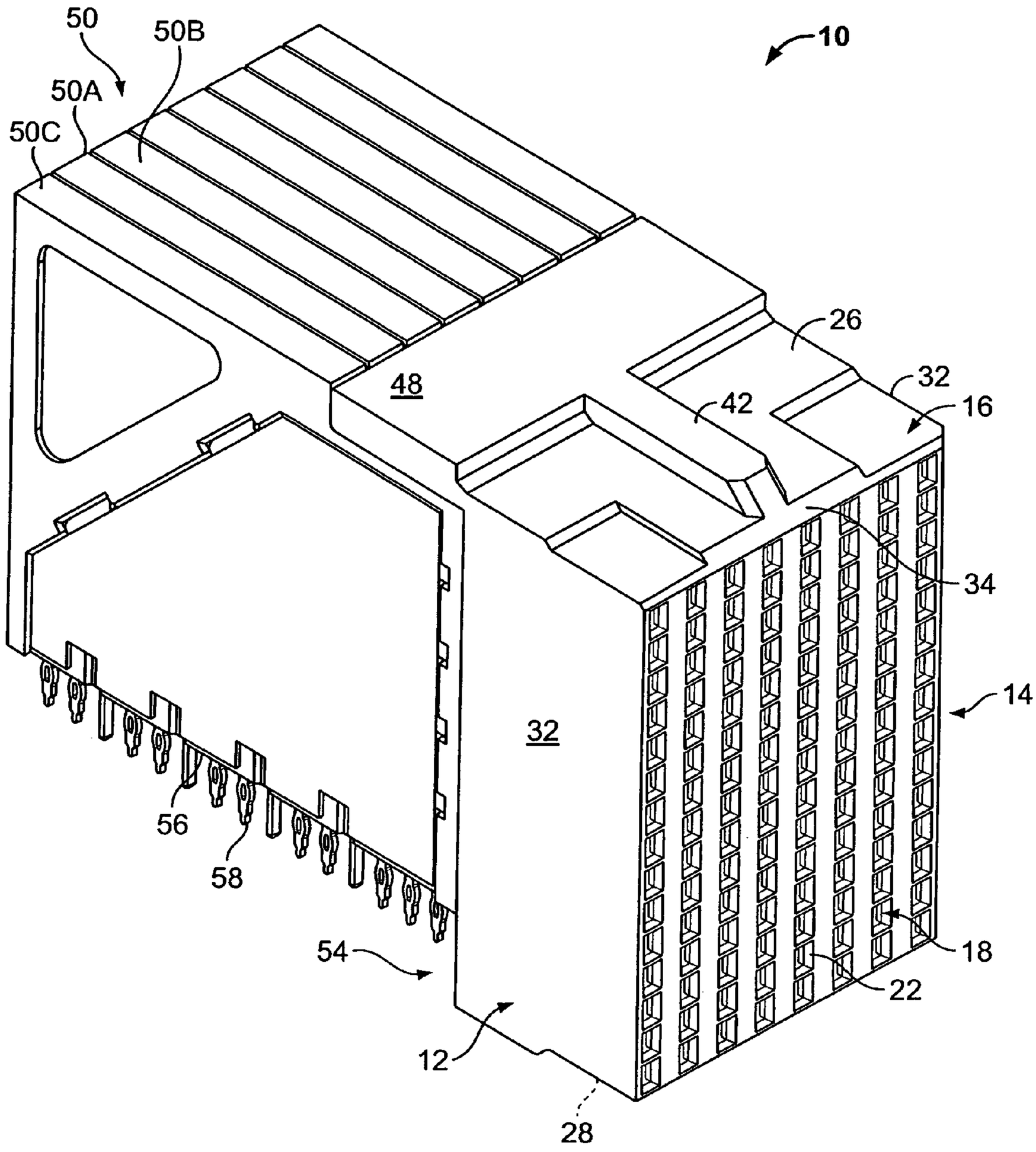


FIG. 1

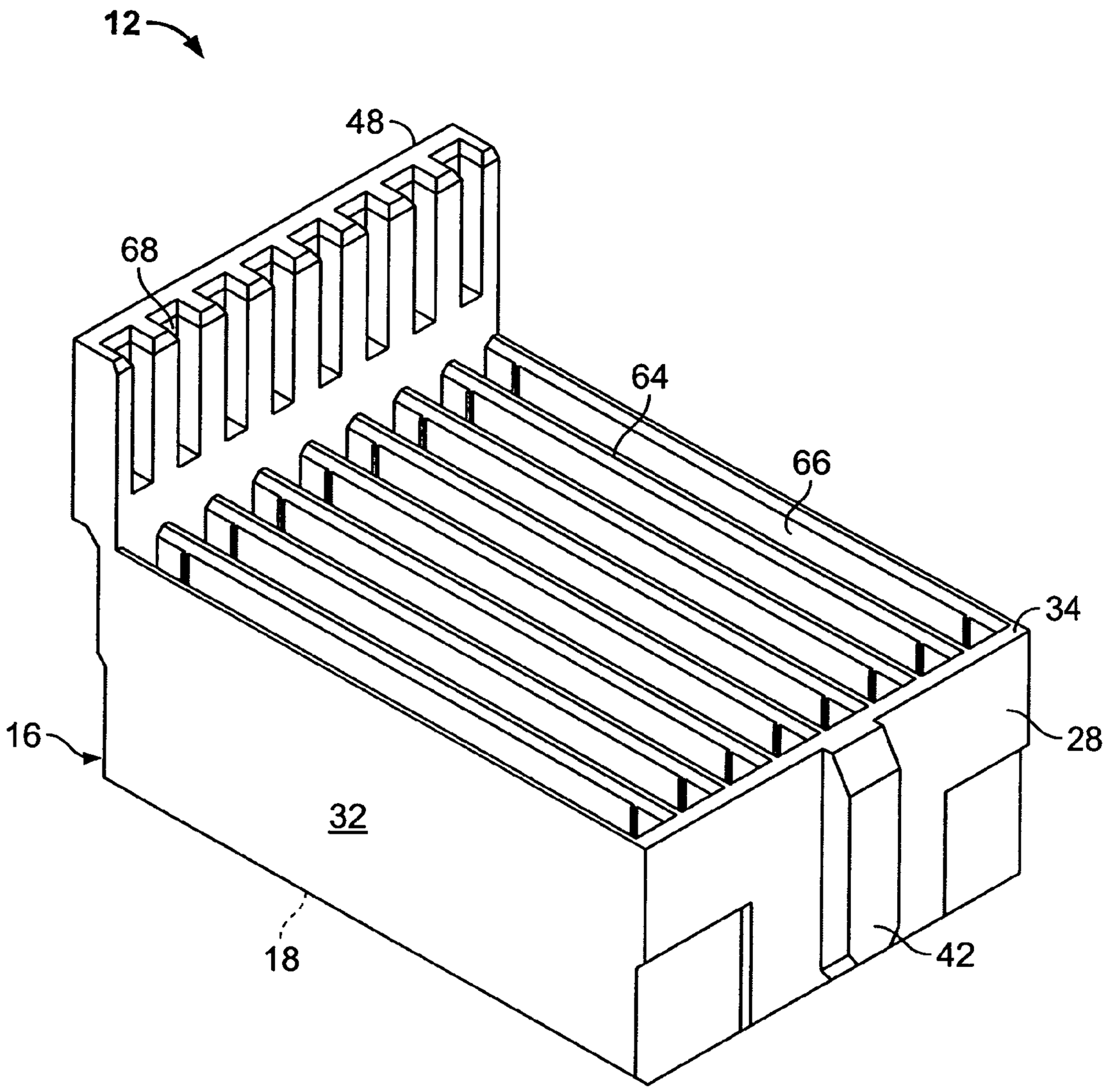
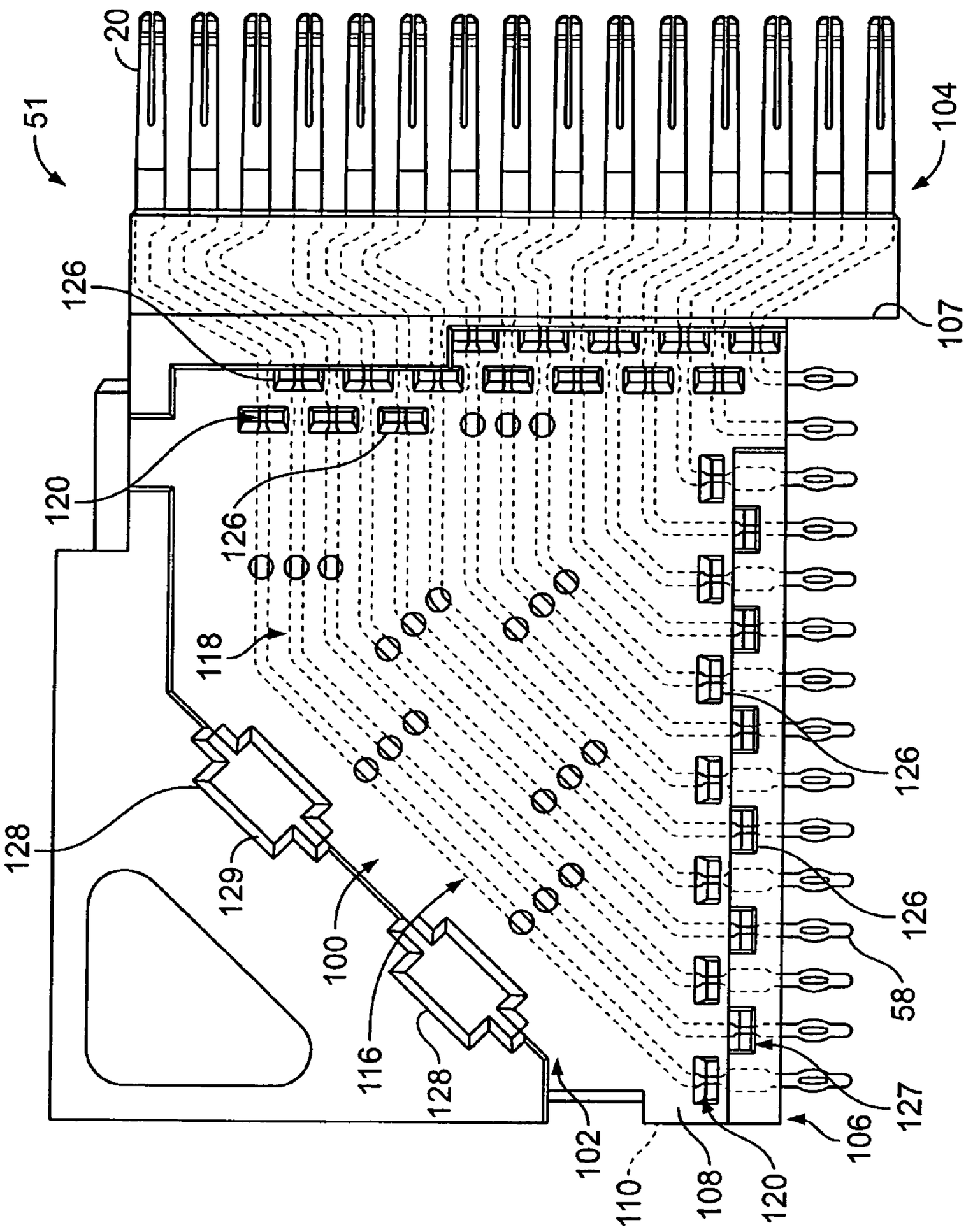


FIG. 2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51
104
126
107
120
126
118
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100
116
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110
108
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106
127

FIG. 3

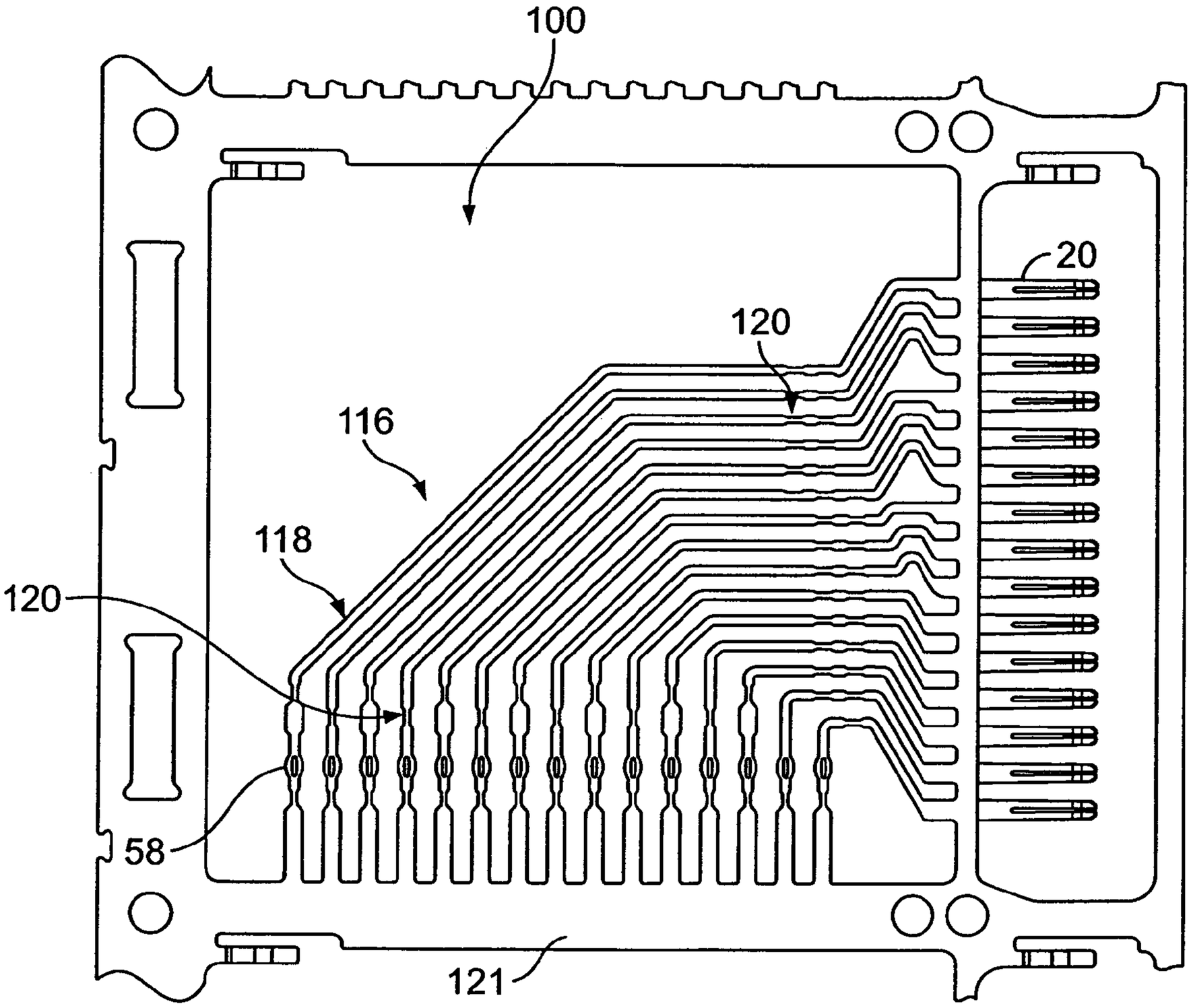


FIG. 4

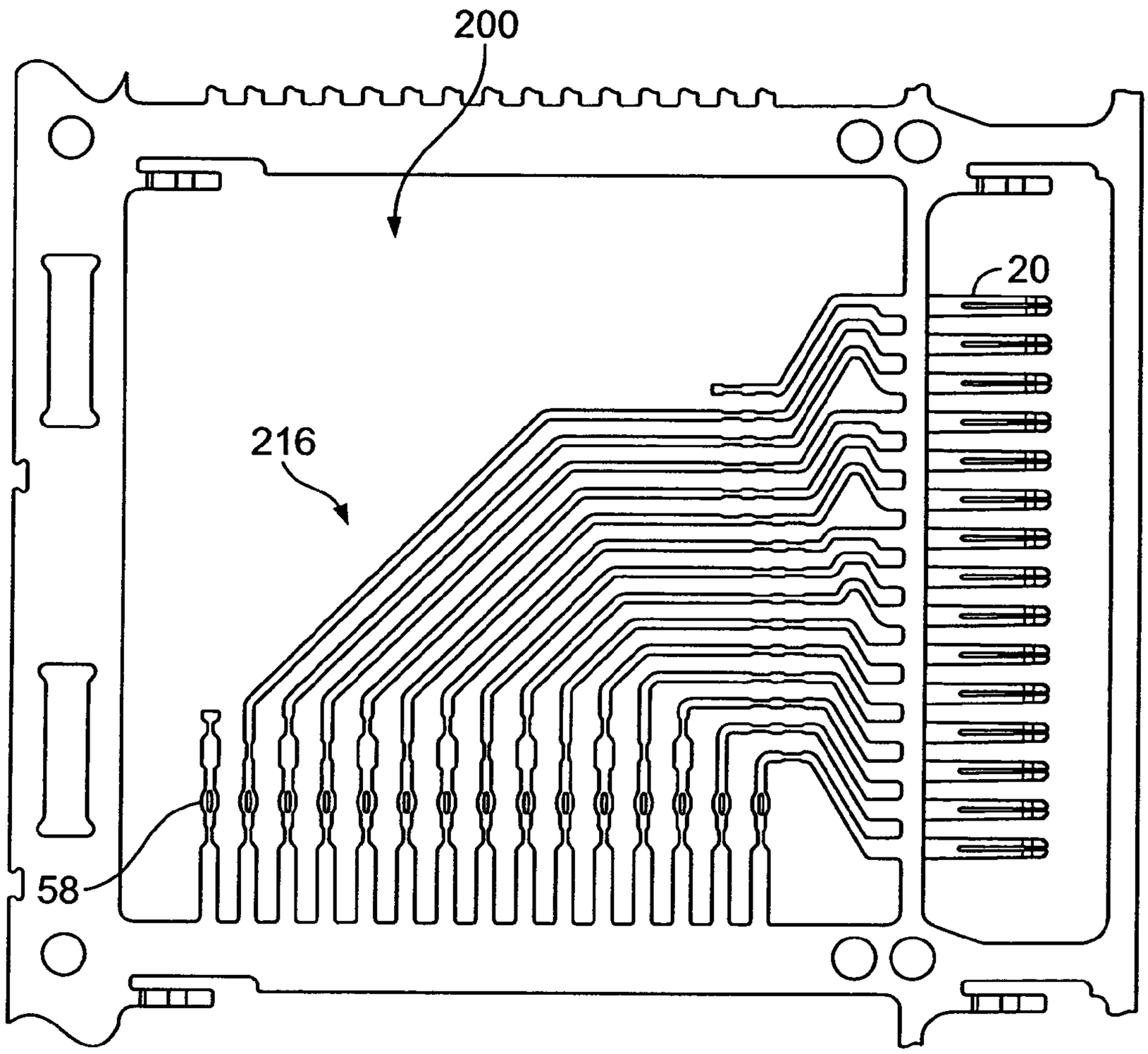


FIG. 5

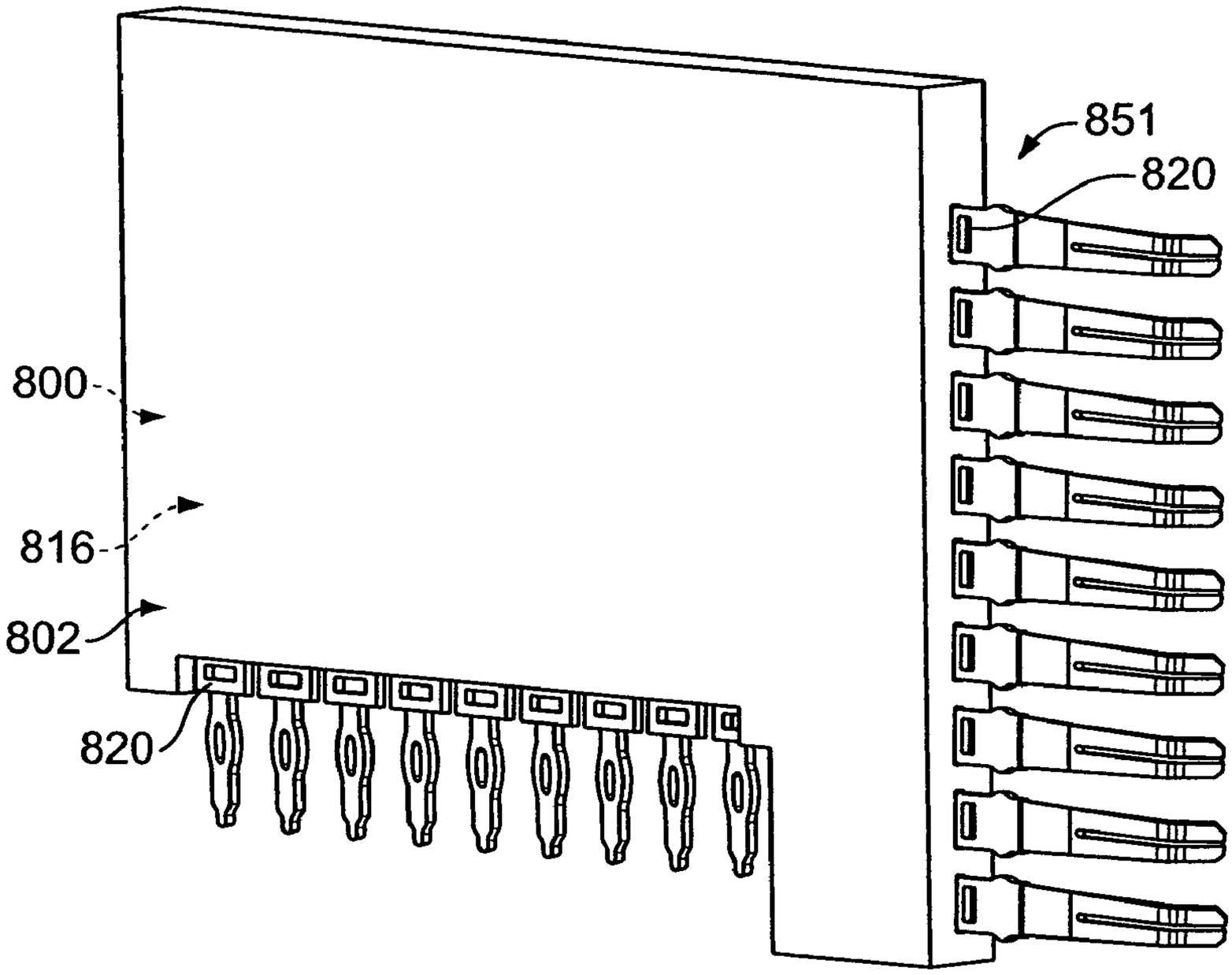


FIG. 6

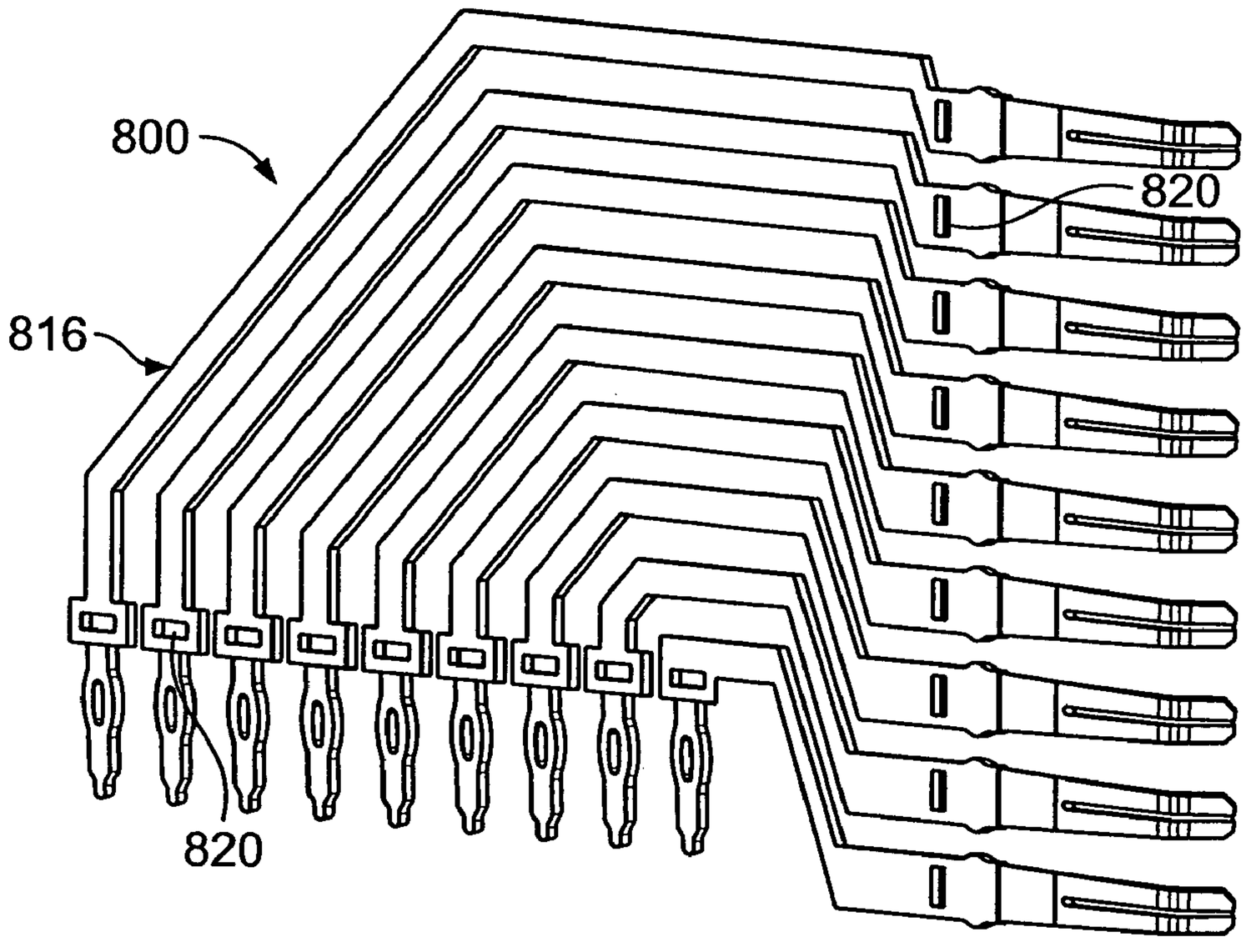
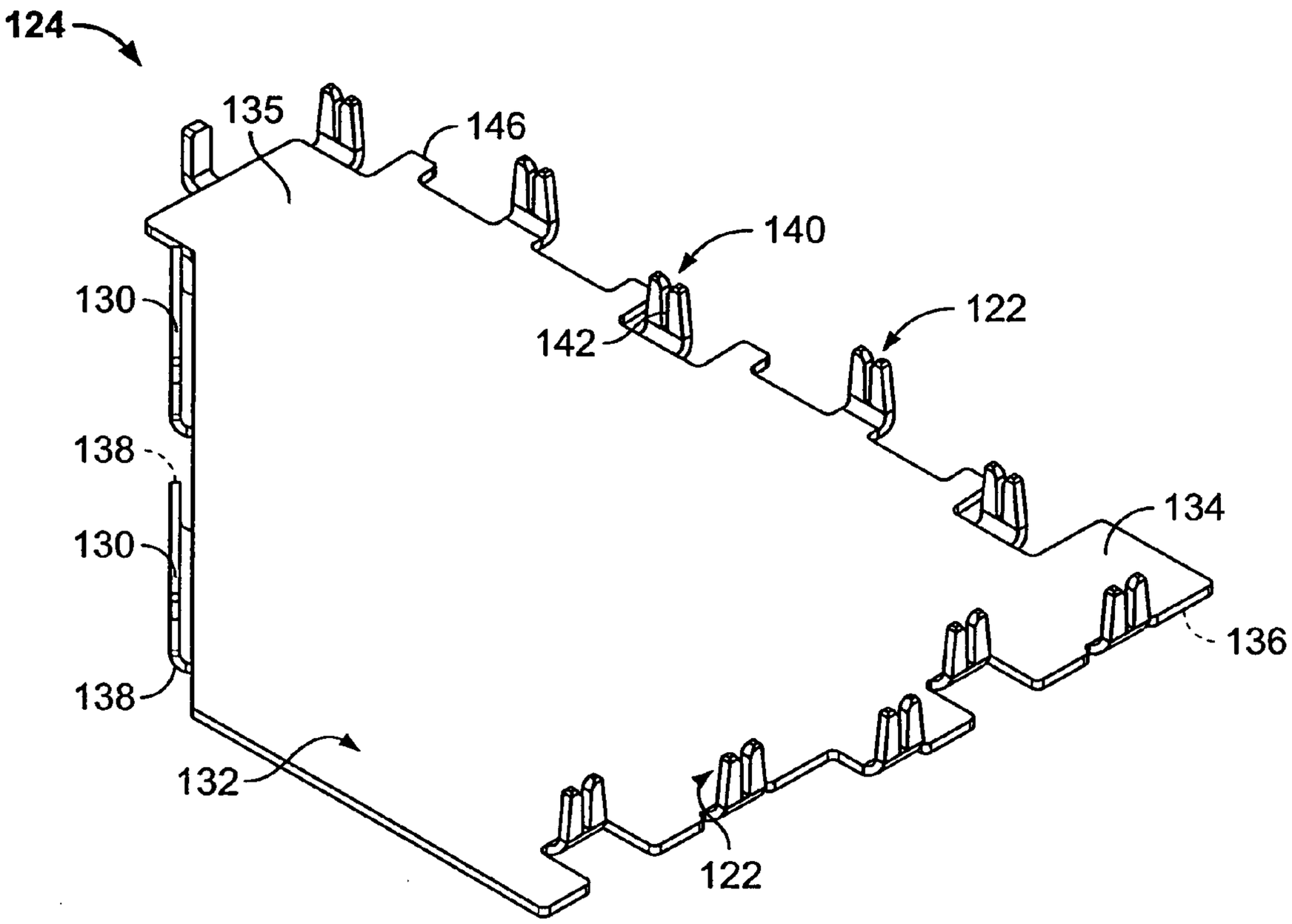


FIG. 7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135
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140
122
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142
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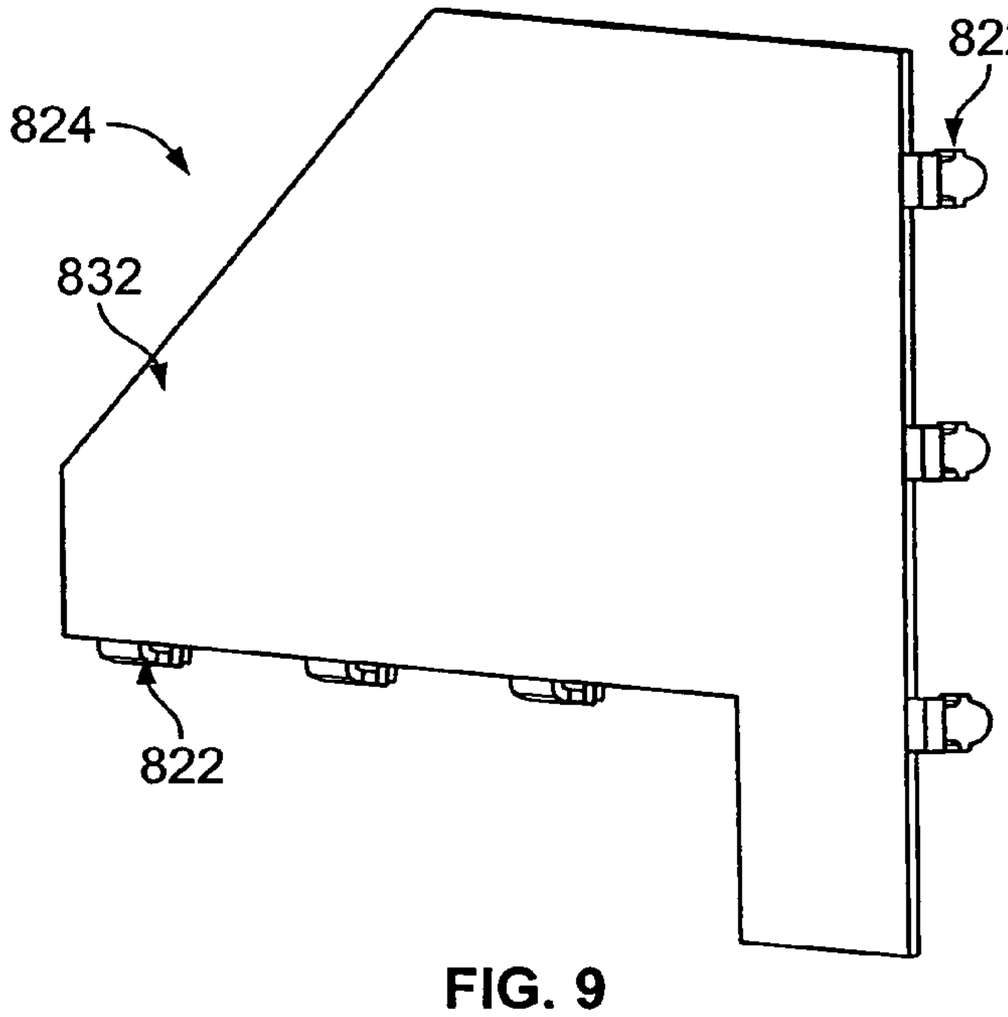
136
138
132
122

FIG. 8


822
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832
822

FIG. 9

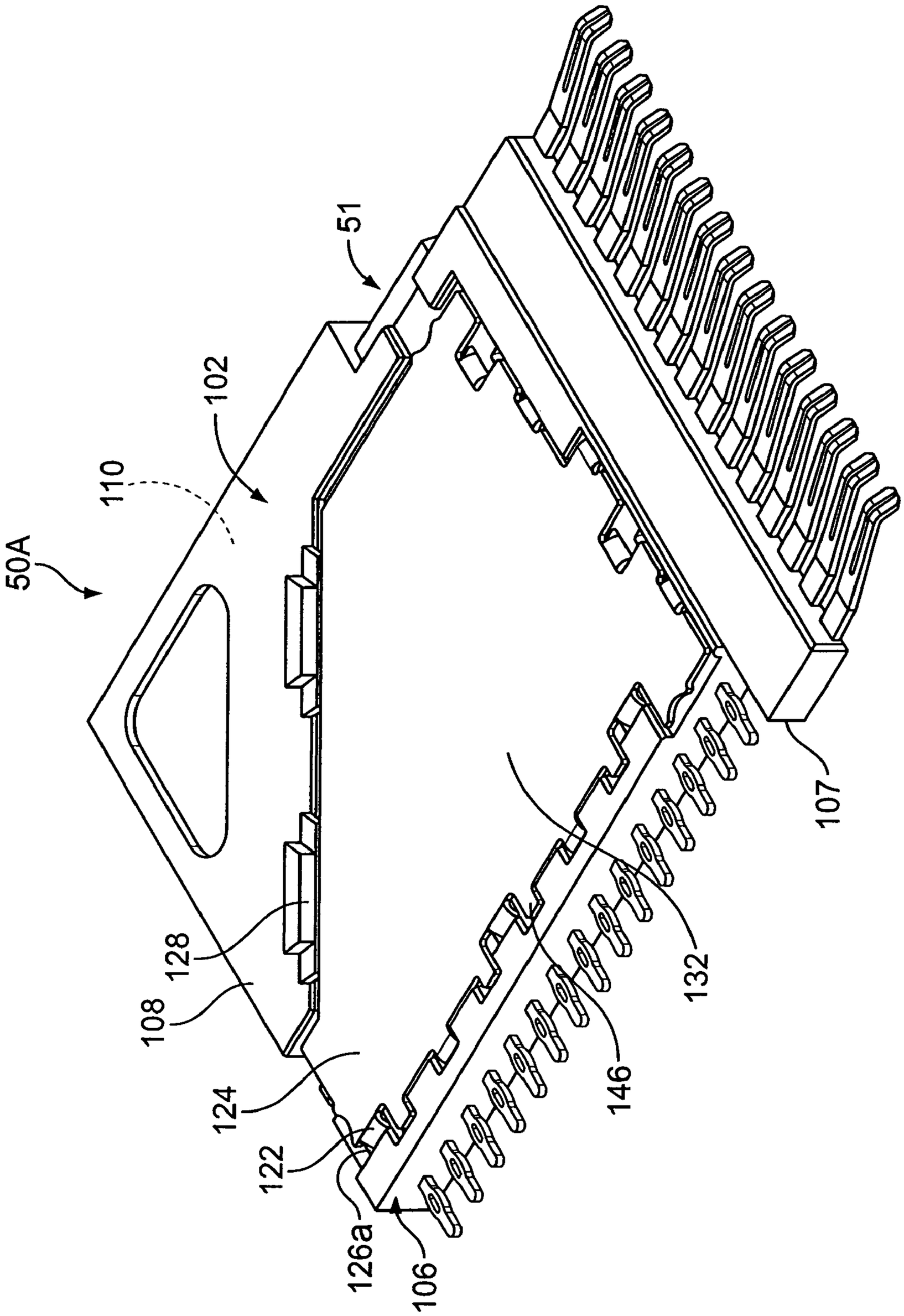
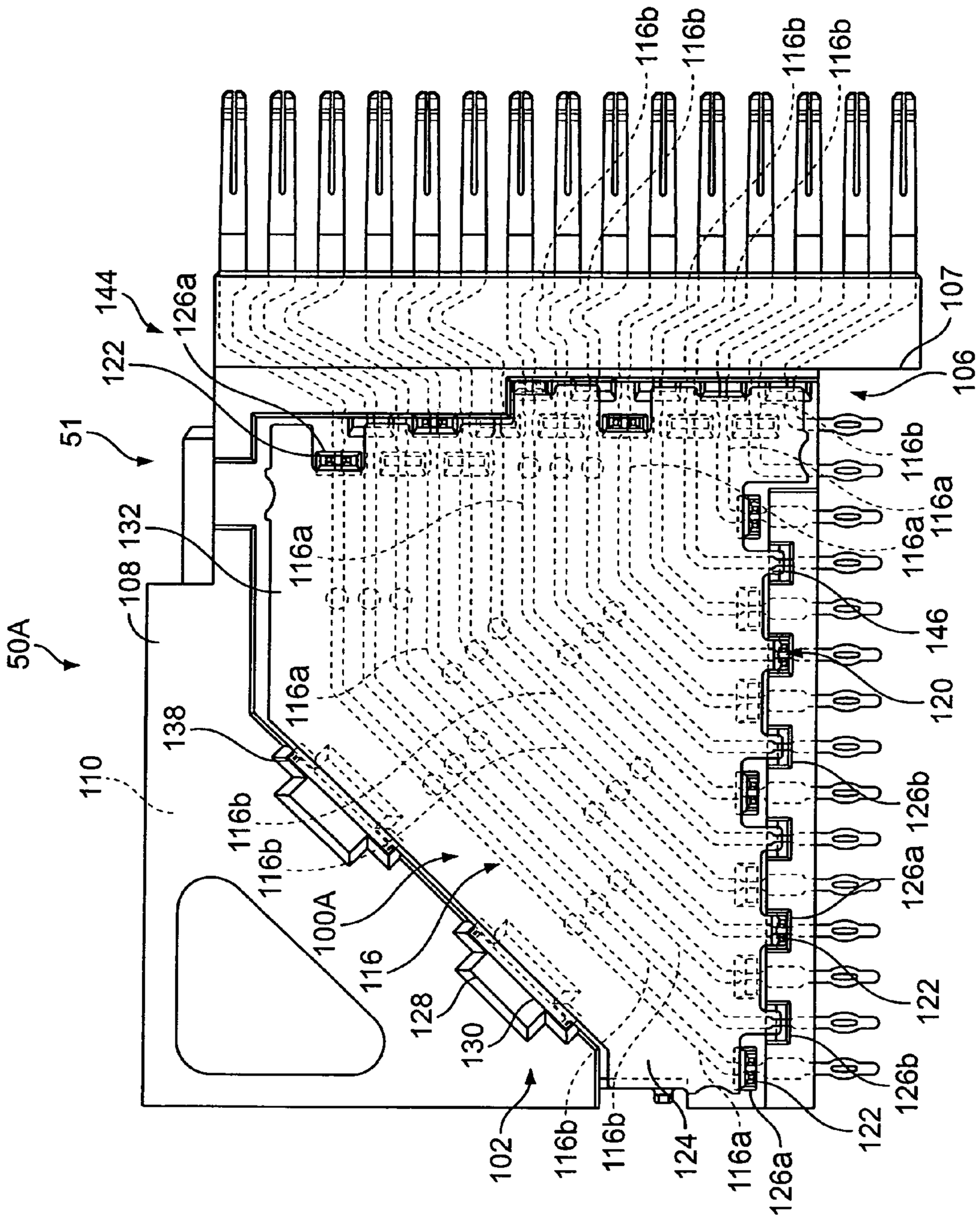


FIG. 10


116b
116b
116b
116b
144
126a
107
122
106
51
108
132
116a
116a
116a
116b
116a
50A
146
120
138
110
116b
116b
126b
126a
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116
122
128
130
126b
102
116b
116b
124
116a
126a
122

FIG. 11

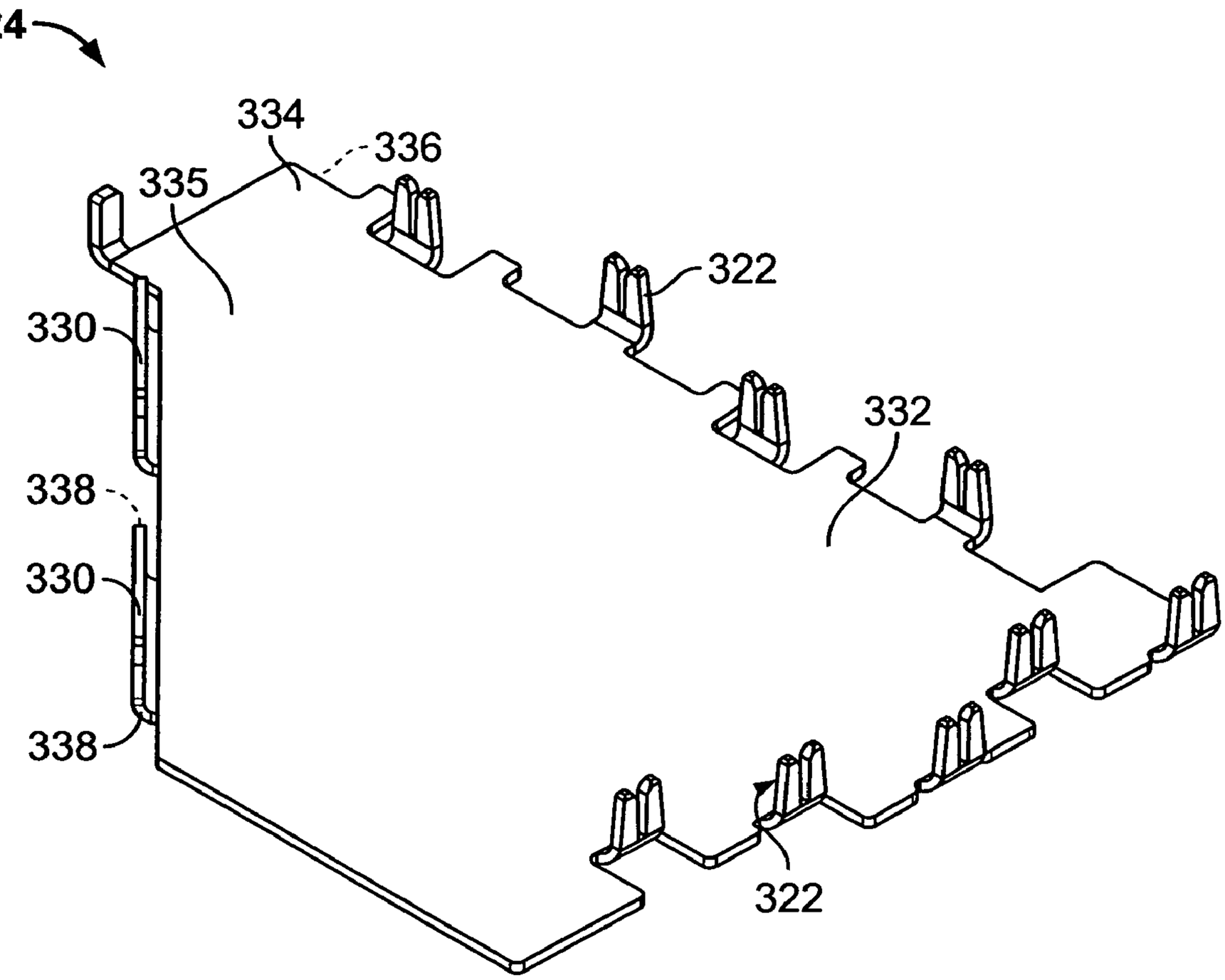

FIG. 12

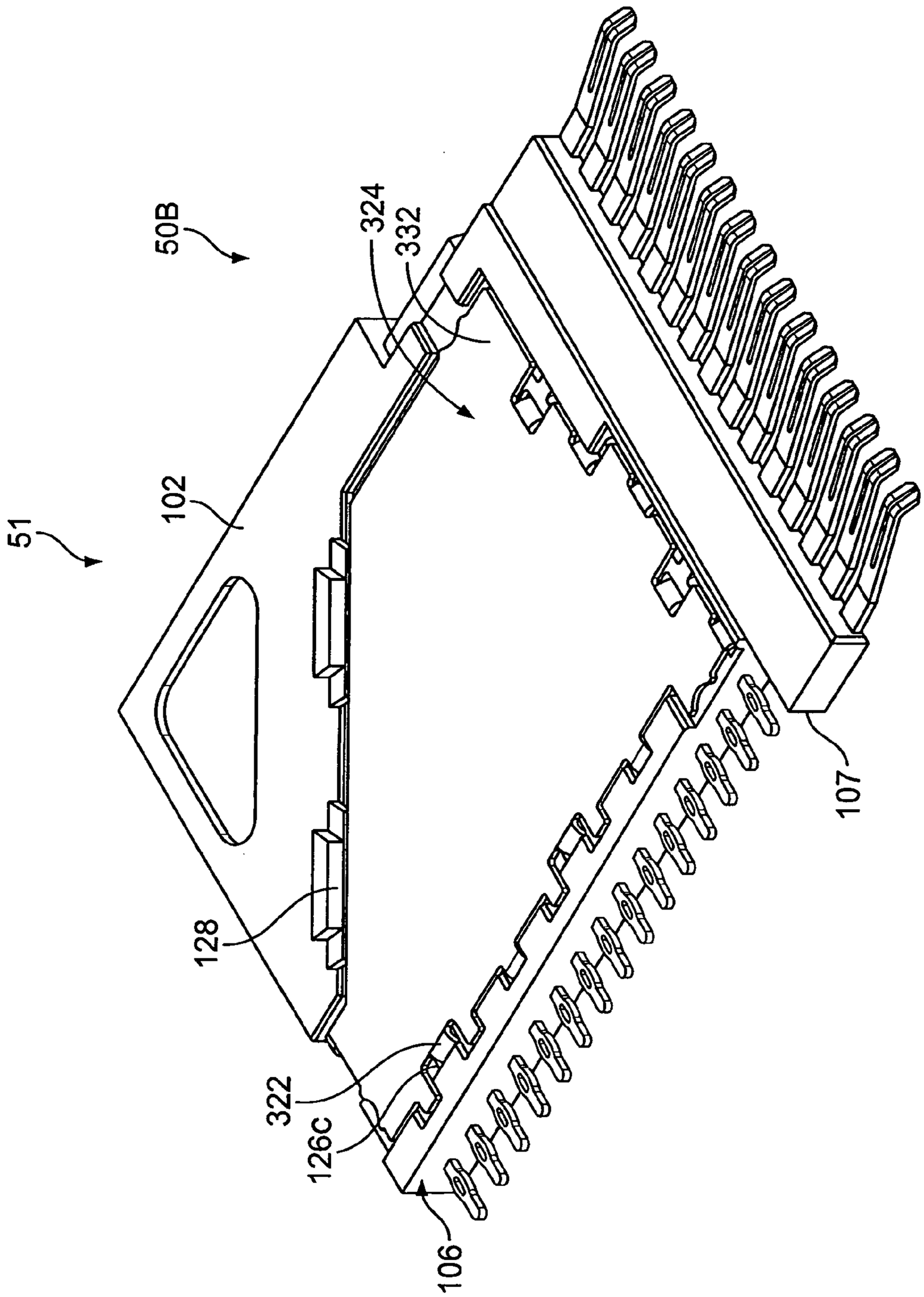

FIG. 13

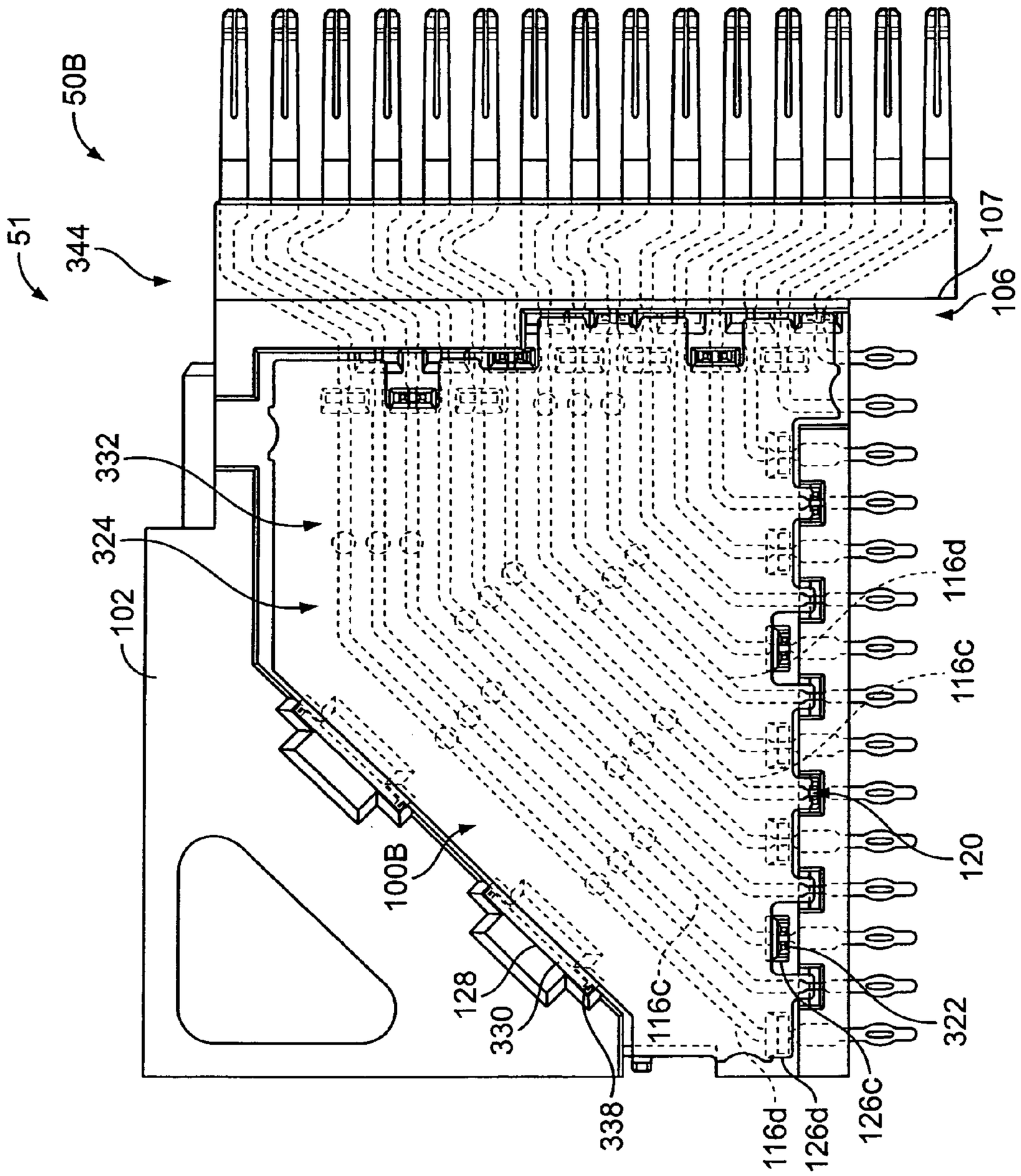
50B
51
344
107
106
332
324
102
100B
128
330
116c
338
116d
126d
126c
322
120

FIG. 14

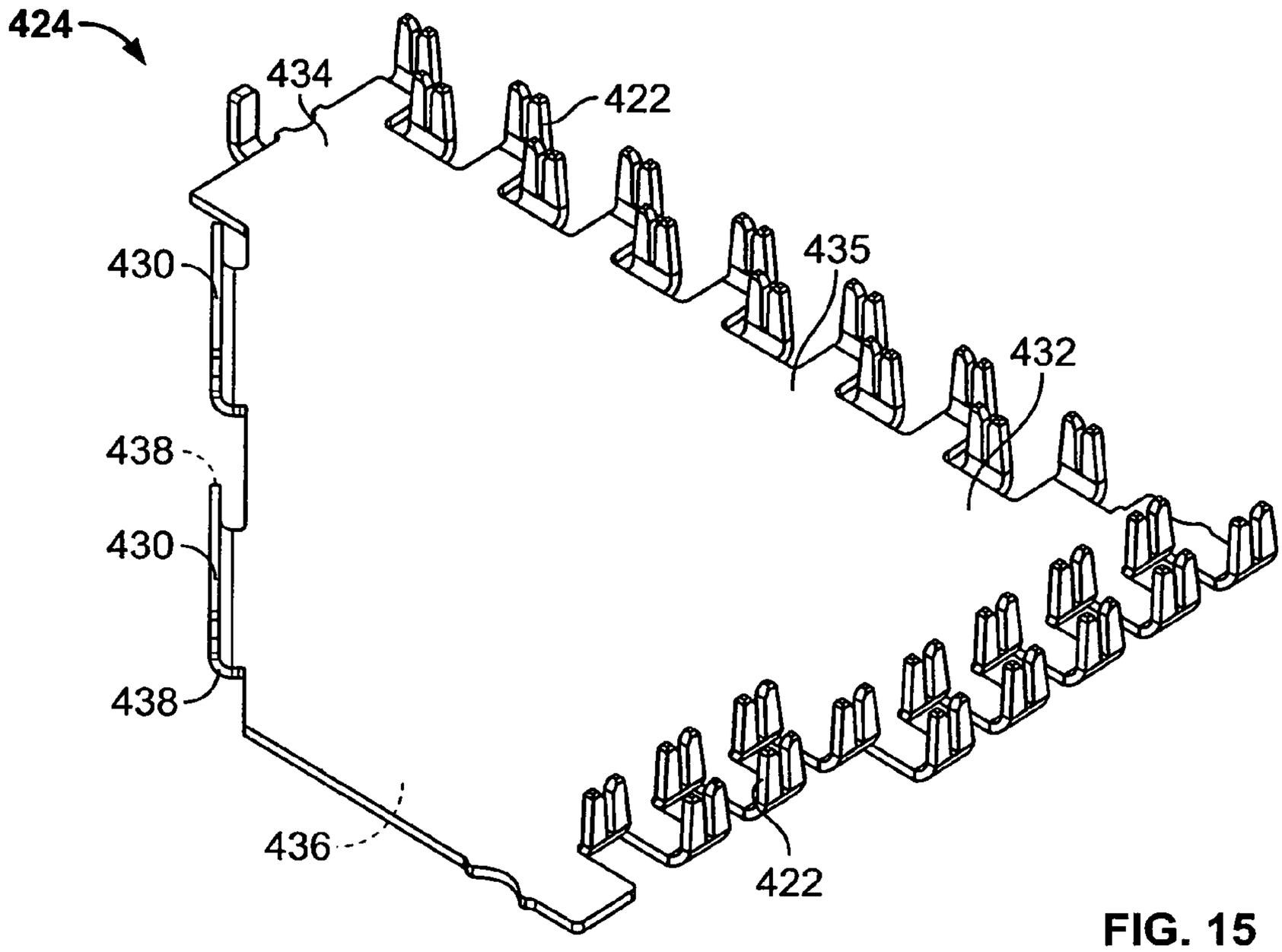
424
434
422
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FIG. 15

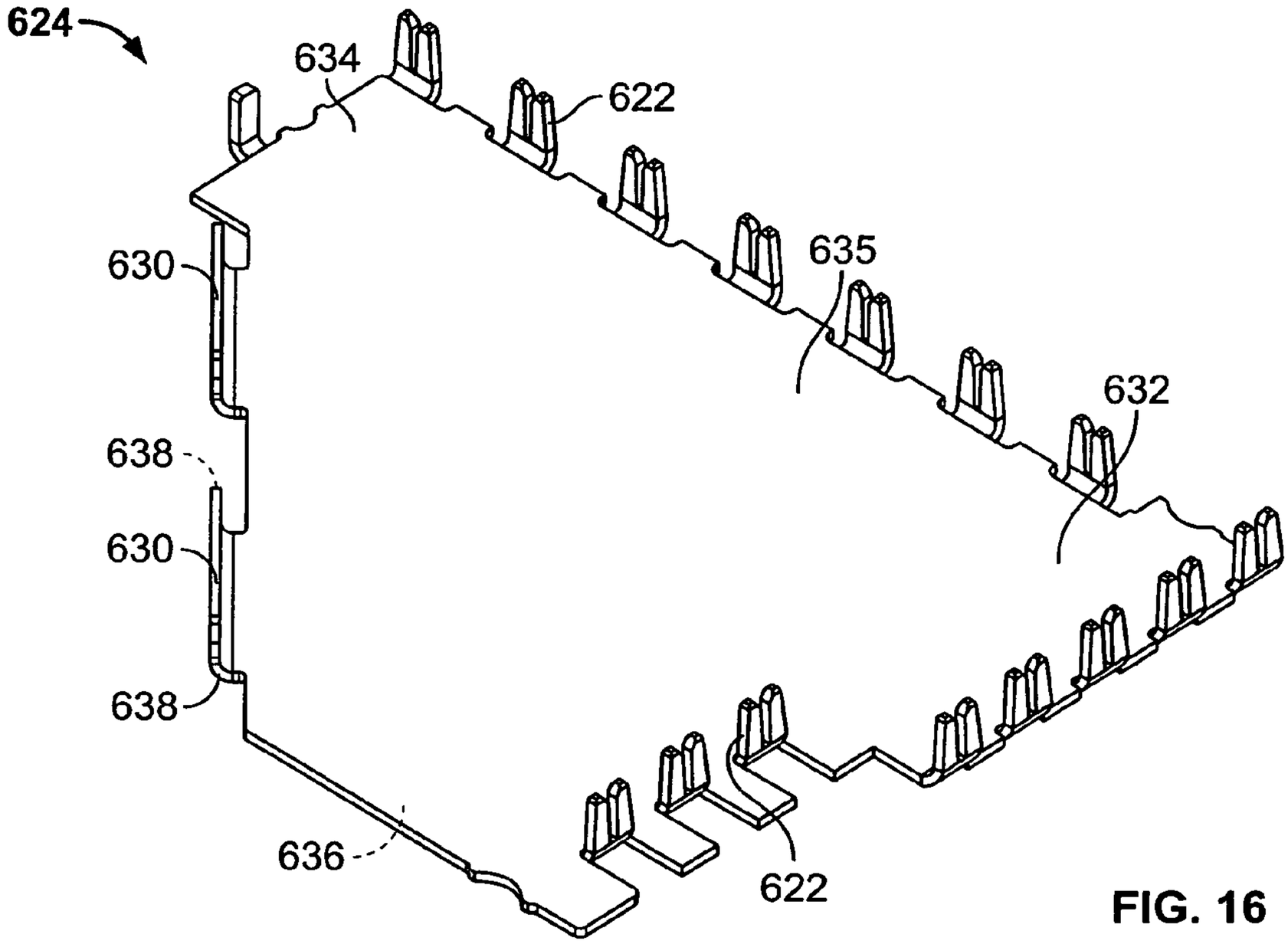
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FIG. 16

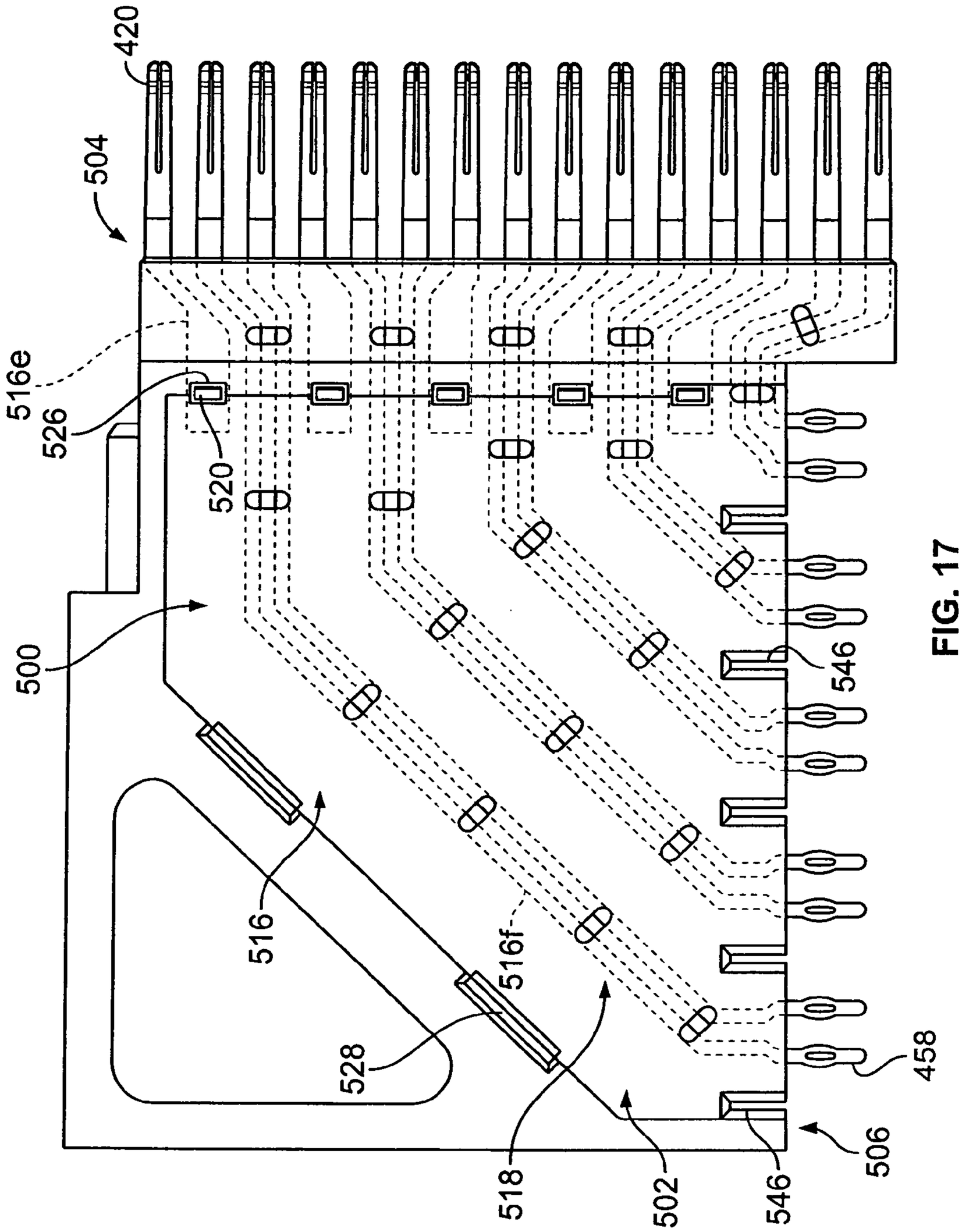
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FIG. 17

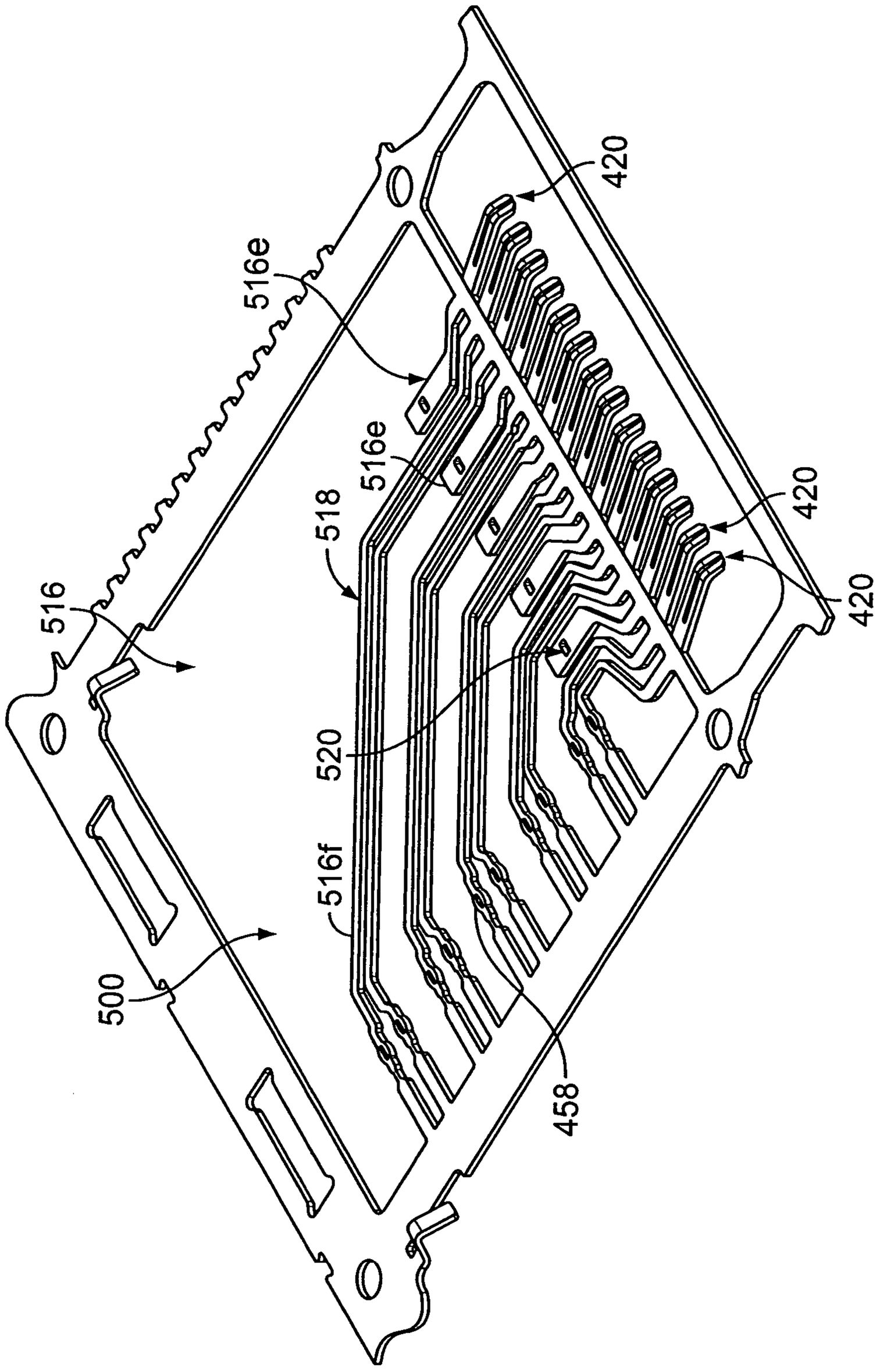


FIG. 18

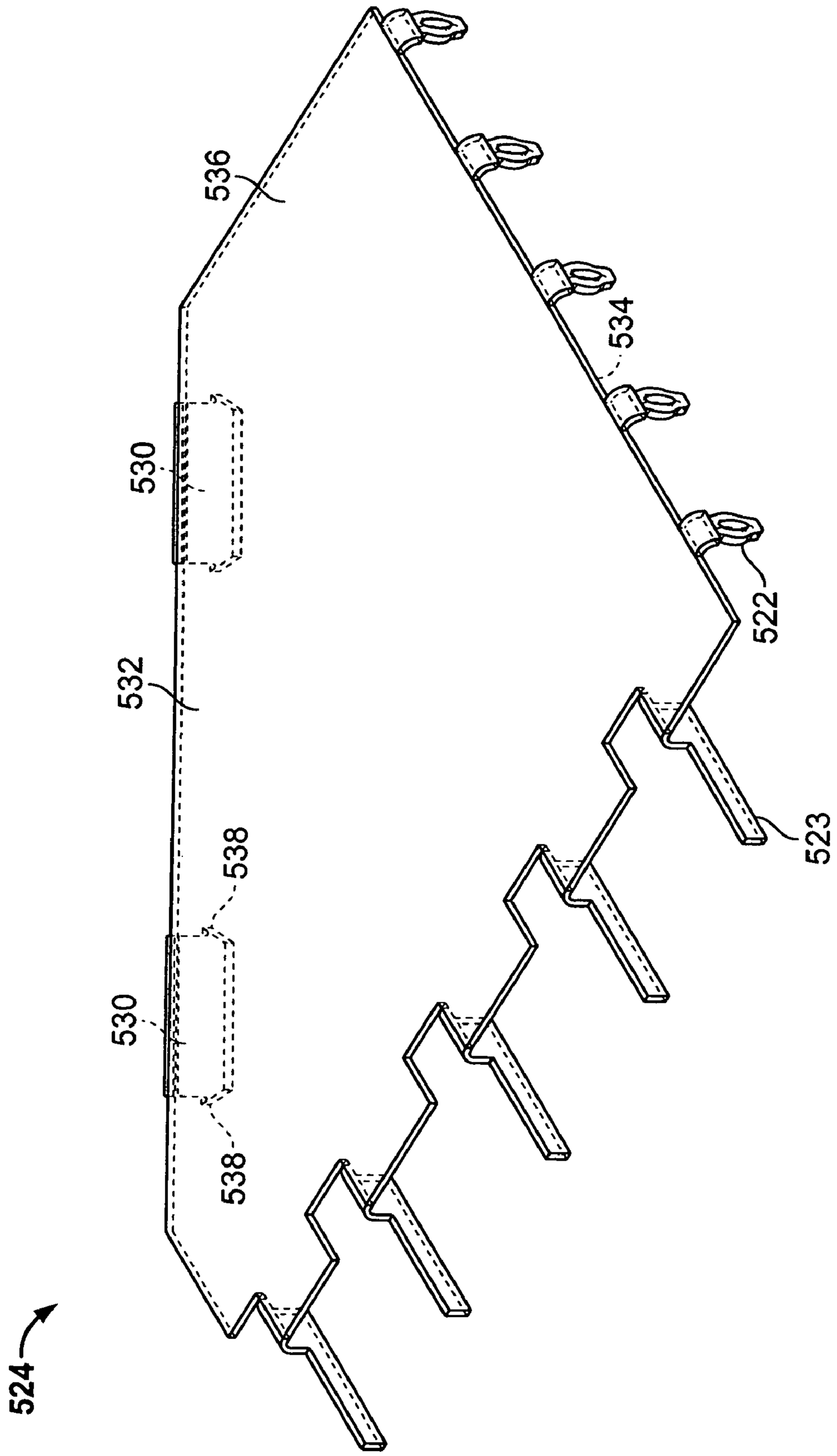
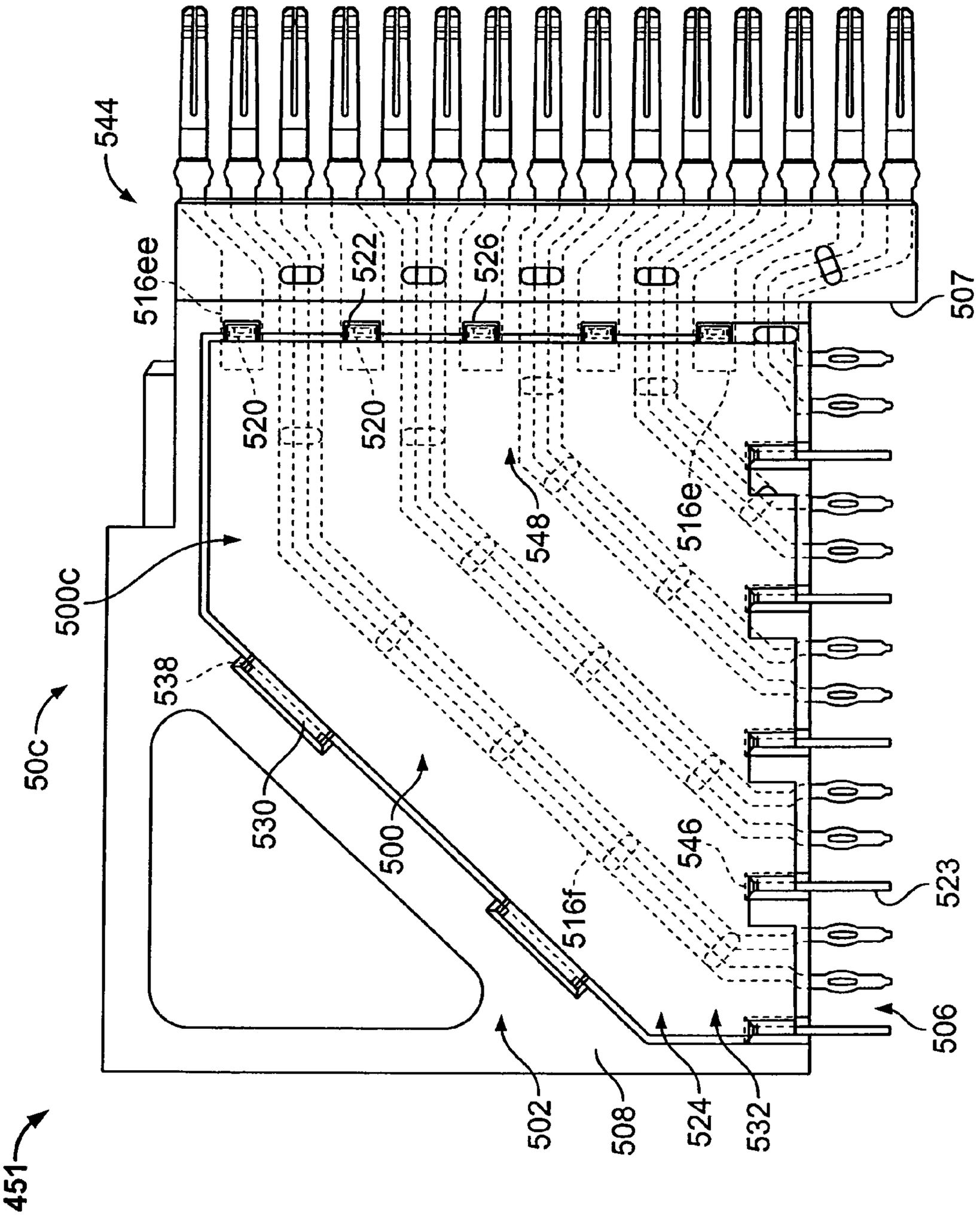


FIG. 19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50c
530
500
546
523
516f
506
502
508
524
532
451

FIG. 20

ELECTRICAL CONNECTOR WITH PROGRAMMABLE LEAD FRAME

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of application Ser. No. 11/800,877 filed May 8, 2007, now U.S. Pat. No. 7,410,393.

BACKGROUND OF THE INVENTION

This invention relates generally to electrical connectors, and more particularly to an electrical connector using a lead frame structure that is programmable into a plurality of different wiring patterns.

With the ongoing trend toward smaller, faster, and higher performance electrical components such as processors used in computers, routers, switches, etc., it has become increasingly important for the electrical interfaces along the electrical paths to also operate at higher frequencies and at higher densities with increased throughput.

In a traditional approach for interconnecting circuit boards, one circuit board serves as a back plane and the other as a daughter board. The back plane typically has a connector, commonly referred to as a header, which includes a plurality of signal contacts which connect to conductive traces on the back plane. The daughter board connector, commonly referred to as a receptacle, also includes a plurality of contacts. Typically, the receptacle is a right angle connector that interconnects the back plane with the daughter board so that signals can be routed therebetween. The right angle connector typically includes a mating face that receives the plurality of signal pins from the header on the back plane, and contacts on a mounting face that connect to the daughter board.

At least some right angle connectors include a plurality of contact modules that are received in a housing. The contact modules typically include a lead frame encased in a dielectric body. The lead frame includes a plurality of terminals that interconnect electrical contacts held on a mating edge of the contact module with corresponding contacts held on a mounting edge of the contact module. Different contact modules of the same connector sometimes have different patterns, sometimes referred to as wiring patterns, of the terminals and/or the mating and mounting edge contacts. For example, adjacent contact modules within the housing may have different patterns of signal, power, and/or ground terminals and/or contacts to enhance the electrical performance of the connector by reducing crosstalk between the adjacent contact modules. However, different lead frames must be designed and manufactured for each of the contact modules having different terminal and/or contact patterns, which may increase a difficulty and/or cost of manufacturing the connector.

There is a need for a lower cost electrical connector that is more easily manufactured.

BRIEF DESCRIPTION OF THE INVENTION

In one embodiment, a contact module assembly is provided for an electrical connector. The contact module assembly includes a lead frame having a plurality of terminals and a commoning member at least partially including an electrically conductive material. The commoning member has a plurality of tabs that are electrically connected to selected ones of the terminals, thereby electrically commoning the selected ones of the terminals. The commoning member can be configured with different patterns of the tabs to selectively configure the lead frame with different patterns of commoned terminals.

In another embodiment, an electrical connector is provided. The electrical connector includes a housing and first and second contact module assemblies held by the housing. Each of the contact module assemblies includes a lead frame having a plurality of terminals. The first contact module assembly includes a first commoning member at least partially including an electrically conductive material. The first commoning member has a plurality of first tabs that are electrically connected to selected ones of the terminals of the first contact module assembly, thereby electrically commoning the selected ones of the terminals of the first contact module assembly. The first tabs are arranged to configure the lead frame of the first contact module assembly with a first pattern of commoned terminals. The second contact module assembly includes a second commoning member at least partially including an electrically conductive material. The second commoning member has a plurality of second tabs that are electrically connected to selected ones of the terminals of the second contact module assembly, thereby electrically commoning the selected ones of the terminals of the second contact module assembly. The second tabs are arranged to configure the lead frame of the second contact module assembly with a second pattern of commoned terminals that is different from the first pattern.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of an exemplary embodiment of an electrical connector.

FIG. **2** is a rear perspective view of an exemplary housing of the electrical connector shown in FIG. **1**.

FIG. **3** is a side view of an exemplary embodiment of a contact module that may be used with the electrical connector shown in FIG. **1**.

FIG. **4** is a side view of an exemplary embodiment of a lead frame for the contact module shown in FIG. **3**.

FIG. **5** is a side view of an exemplary alternative embodiment of a lead frame that may be used with the electrical connector shown in FIG. **1**.

FIG. **6** is a perspective view of an exemplary alternative embodiment of a contact module that may be used with the electrical connector shown in FIG. **1**.

FIG. **7** is a perspective view of an exemplary alternative embodiment of a lead frame for the contact module shown in FIG. **6**.

FIG. **8** is a perspective view of an exemplary embodiment of a commoning member that may be used with the contact module shown in FIG. **3**.

FIG. **9** is a perspective view of an exemplary alternative embodiment of a commoning member that may be used with the contact module shown in FIG. **6**.

FIG. **10** is a perspective view of the commoning member shown in FIG. **8** mounted on the contact module shown in FIG. **3**.

FIG. **11** is a top plan view of the contact module assembly shown in FIG. **10**.

FIG. **12** is a perspective view of an exemplary embodiment of another commoning member that may be used with the contact module shown in FIG. **3**.

FIG. **13** is a perspective view of the commoning member shown in FIG. **12** mounted on the contact module shown in FIG. **3**.

FIG. **14** is a top plan view of the contact module assembly shown in FIG. **13**.

FIG. **15** is a perspective view of an exemplary embodiment of another commoning member that may be used with the contact module shown in FIG. **3**.

FIG. **16** is a perspective view of an exemplary embodiment of another commoning member that may be used with the contact module shown in FIG. **3**.

FIG. **17** is a side view of an exemplary alternative embodiment of a contact module that may be used with the electrical connector shown in FIG. **1**.

FIG. **18** is a perspective view of an exemplary alternative embodiment of a lead frame for the contact module shown in FIG. **17**.

FIG. **19** is a perspective view of an exemplary embodiment of a commoning member that may be used with the contact module shown in FIG. **17**.

FIG. **20** is a perspective view of the commoning member shown in FIG. **19** mounted on the contact module shown in FIG. **17**.

DETAILED DESCRIPTION OF THE INVENTION

FIG. **1** illustrates an exemplary embodiment of an electrical connector **10**. While the connector **10** will be described with particular reference to a receptacle connector, it is to be understood that the benefits herein described are also applicable to other connectors in alternative embodiments. The following description is therefore provided for purposes of illustration, rather than limitation, and is but one potential application of the inventive concepts herein.

The connector **10** includes a dielectric housing **12** having a forward mating end **14** that includes a shroud **16** and a mating face **18**. The mating face **18** includes a plurality of mating contacts **20** (shown in FIGS. **3** and **4**), such as, for example, contacts within contact cavities **22**, that are configured to receive corresponding mating contacts (not shown) from a mating connector (not shown). The shroud **16** includes an upper surface **26** and a lower surface **28** between opposed sides **32**. The upper and lower surfaces **26** and **28**, respectively, each include a chamfered forward edge portion **34**. An alignment rib **42** is formed on the upper shroud surface **26** and lower shroud surface **28**. The chamfered edge portion **34** and the alignment ribs **42** cooperate to bring the connector **10** into alignment with the mating connector during the mating process so that the contacts in the mating connector are received in the contact cavities **22** without damage.

The housing **12** also includes a rearwardly extending hood **48**. A plurality of contact module assemblies **50** are received in the housing **12** from a rearward end **54**. The contact module assemblies **50** define a connector mounting face **56**. The connector mounting face **56** includes a plurality of contacts **58**, such as, but not limited to, pin contacts, or more particularly, eye-of-the-needle-type contacts, that are configured to be mounted to a substrate (not shown), such as, but not limited to, a circuit board. In an exemplary embodiment, the mounting face **56** is substantially perpendicular to the mating face **18** such that the connector **10** interconnects electrical components that are substantially at a right angle to one another. In one embodiment, the housing **12** holds two or more different types of contact module assemblies **50**, such as, but not limited to, contact module assemblies **50**A, **50**B, **50**C (shown in FIGS. **10** and **11**, **13** and **14**, and **18**, respectively), a contact module assembly (not shown) formed using the commoning member **424** (FIG. **15**), and/or a contact module assembly (not shown) formed using the commoning member **624** (FIG. **16**). Alternatively, the housing **12** may hold only a single type of contact module assemblies **50**, such as, but not limited to, any of the contact module assemblies **50**A, **50**B, **50**C, the contact module assembly formed using the commoning member **424**, or the contact module assembly formed using the commoning member **624**.

FIG. **2** illustrates a rear perspective view of the housing **12**. The housing **12** includes a plurality of dividing walls **64** that define a plurality of chambers **66**. The chambers **66** receive a forward portion of the contact module assemblies **50** (FIG. **1**). A plurality of slots **68** are formed in the hood **48**. The chambers **66** and slots **68** cooperate to stabilize the contact module assemblies **50** when the contact module assemblies **50** are loaded into the housing **12**. In the exemplary embodiment, the chambers **66** each have about an equal width and the slots **68** each have about an equal width. However, some or all of the chambers **66**, and/or some or all of the slots **68**, may different widths for accommodating differently sized contact module assemblies **50**. The chambers **66** and slots **68** may optionally extend substantially an entire length of the contact module assemblies **50** such that the chamber walls separate adjacent contact module assemblies **50**.

FIG. **3** illustrates an exemplary embodiment of a contact module **51** that includes an exemplary embodiment of an internal lead frame **100**, shown in phantom outline, and a dielectric body **102**. FIG. **4** illustrates the lead frame **100** that is held within the contact module **51**. The lead frame **100** includes a plurality of terminals **116** enclosed within the body **102**. The mating contacts **20** extend from a mating edge portion **104** of the body **102** and the lead frame **100**, and the mounting contacts **58** extend from a mounting edge portion **106** of the body **102** and the lead frame **100**. The mounting edge portion **106** intersects with a rearward facing end wall **107** proximate the mating edge portion **104**. Alternatively, the mating edge portion **104** may intersect the mounting edge **106**. The body **102** includes opposite side portions **108** and **110** that extend substantially parallel to and along the lead frame **100**. In some embodiments, the body **102** is manufactured using an over-molding process. During the molding process, the lead frame **100** is encased in a dielectric material, which forms the body **102**. As illustrated in FIG. **4**, prior to over-molding the lead frame **100** is preferably stabilized by an integral carrier strip **121** which is removed and discarded after the over-molding process that creates the body **102**. In the exemplary embodiment, the mating and mounting edge portions **104** and **106**, respectively, extend substantially perpendicular to each other. However, the mating and mounting edge portions **104** and **106**, respectively, may extend any direction relative to each other, such as, but not limited to, substantially parallel.

The lead frame **100** includes the plurality of terminals **116** that extend along predetermined paths to electrically connect each mating contact **20** to a corresponding mounting contact **58**. The terminals **116** include the mating and mounting contacts **20** and **58**, respectively, and an intermediate terminal portion **118**, which extends between the mating and mounting contacts **20** and **58**, respectively. In some embodiments, the intermediate terminal portion **118** extends obliquely between the mating and mounting contacts **20** and **58**, respectively. For example, in the exemplary embodiment, the intermediate terminal portion **118** extends at approximately a forty-five degree angle between the mating and mounting contacts **20** and **58**, respectively. The terminals **116** may be either signal terminals, ground terminals, or power terminals. The lead frame **100** may include any number of terminals **116**, any number of which may be selected as signal terminals, ground terminals, or power terminals according the desired wiring pattern programmed as described below. Optionally, adjacent signal terminals may function as differential pairs, and each differential pair may be separated by a ground terminal.

In alternative embodiments, at least a portion of the intermediate terminal portion **118** of one or more of any ground terminals may be removed such that the intermediate terminal

portion **118** of such a ground terminal(s) does not connect the mating and mounting contacts **20** and **58**, respectively, of the ground terminal(s). FIG. **5** illustrates an alternative embodiment of a lead frame **200** wherein the intermediate terminal portion of one of the terminals **216** has been removed such that the mating and mounting contacts **20** and **58**, respectively, of the terminal **216** are not connected.

In the exemplary embodiment of FIGS. **3** and **4**, each of the terminals **116** includes a necked-down portion **120** that is engaged by a corresponding electrically conductive tab **122**, **322**, **422**, or **622** (FIGS. **8**, **12**, **15**, and **16**, respectively) of a respective commoning member **124**, **324**, **424**, or **624** (FIGS. **8**, **10**, and **11**, **12-14**, **15**, and **16**, respectively), as will be described in more detail below. However, the terminals **116** may each have any suitable configuration, arrangement, and/or the like, and/or may include any suitable structure and/or means, that enable the terminals **116** to directly physically engage and electrically connect to the corresponding tab **122**, **322**, **422**, or **622**. For example, in an alternative embodiment shown in FIGS. **6** and **7**, an exemplary alternative embodiment of a contact module **851** includes a lead frame **800** having a plurality of terminals **816**. Each terminal **816** includes a pair of openings **820** therein for each receiving a tab **822** (FIG. **9**) of a commoning member **824** (FIG. **9**), as will be described in more detail below. As illustrated in FIG. **6**, a dielectric body **802** that encloses a portion of the terminals **816** does not enclose the openings **820**, such that the openings **820** are exposed. Alternatively, each of the openings **820** within the terminals **816** is exposed by a corresponding opening (not shown) within the dielectric body **802**.

Referring again to FIG. **3**, the dielectric body **102** includes a plurality of openings **126** that each exposes the necked-down portion **120** of a corresponding one of the terminals **116**. The openings **126** may optionally include a chamfered edge portion **127** to facilitate reception of the corresponding tab **122**, **322**, **422**, or **622** therein. The dielectric body **102** also includes a pair of openings **128** for receiving a corresponding retention member **130**, **330**, **430**, or **630** (FIGS. **8**, **12**, **15**, and **16**, respectively) of the commoning member **124**, **324**, **424**, or **624**, respectively, to facilitate holding the commoning member **124**, **324**, **424**, or **624** on the contact module **51**, as will be described in more detail below. In some embodiments, in addition or alternative to the retention members **130**, **330**, **430**, or **630**, the engagement between the tabs **122**, **322**, **422**, or **622** and the corresponding terminals **116** facilitate holding the commoning member **124**, **324**, **424**, or **624** on the contact module **51**. The openings **128** may have any suitable shape that enables the openings **128** to function as described and/or illustrated herein. Although two openings **128** are shown, the dielectric body **102** may include any number of openings **128**. Optionally, the openings **128** may include a chamfered edge portion **129** to facilitate reception of the corresponding retention member **130**, **330**, **430**, or **630** therein.

The contact module and lead frame embodiments described and/or illustrated herein provide contact modules having a lead frame structure that is selectively programmable with a plurality of different wiring patterns. Specifically, and with reference to the exemplary embodiment of FIGS. **3** and **4**, each of the lead frame terminals **116** is selectively configurable as a signal terminal, a ground terminal, or a power terminal. The lead frame **100** is selectively configurable into different patterns of signal, ground, and/or power terminals using different commoning members (e.g., the commoning members **124**, **324**, **424**, and **624**, shown in FIGS. **8**, **10**, and **11**, **12-14**, **15**, and **16** respectively). Specifically, tabs of the commoning members engage and electrically connect to selected terminals **116** of the lead frame **100** to electrically common the selected terminals **116**. Different commoning members can be configured with different patterns of tabs to selectively configure the lead frame **100** with different patterns of commoned terminals.

FIG. **8** illustrates an exemplary embodiment of the commoning member **124**. The commoning member **124** is fabricated at least partially from an electrically conductive material. The commoning member **124** includes a body **132** having opposite side portions **134** and **136** and a shield plate **135**, which extends coplanar with the lead frame **100** when the commoning member **124** is mounted on the contact module **51**. A pair of the retention members **130** extend outwardly on the side portion **134** for reception within the openings **128** (FIG. **3**) within the dielectric body **102** (FIG. **3**) to facilitate holding the commoning member **124** on the contact module **51** (FIG. **3**). Although the retention members **130** may include any suitable structure, means, configuration, arrangement, and/or the like, in the exemplary embodiment the retention members **130** each include a pair of opposite hooks **138** that are configured to engage the dielectric body **102** adjacent the corresponding opening **128** to facilitate holding the commoning member **124** on the contact module **51**. Although two retention members **130** are shown, the commoning member body **132** may include any number of retention members **130** for reception within any number of openings **128** within the dielectric body **102**. Additionally or alternatively, the dielectric body **102** may include one or more retention members (not shown) extending outwardly therefrom for reception within one or more openings (not shown) within the commoning member body **132**.

The commoning member body **132** also includes a plurality of the electrically conductive tabs **122** extending outwardly on the side portion **134**. In the exemplary embodiment of FIG. **8**, the tabs **122** are each insulation displacement contacts (IDCs) that include a forked portion **140** that defines an opening **142**. When the commoning member **124** is mounted on the contact module **51** as described below, the necked-down portion **120** (FIGS. **3** and **4**) of the corresponding terminal **116** (FIGS. **3** and **4**) is received within the opening **142** and engages the forked portion **140** of each tab **122** to directly physically engage and electrically connect the tab **122** to the corresponding terminal **116**. However, the tabs **122** may each be any suitable type of electrical contact, and may each have any suitable structure and/or means, that enable the tabs **122** to directly physically engage and electrically connect to the corresponding terminal **116**, such as, but not limited to, IDC, pin, and/or eye of the needle contacts. For example, FIG. **9** illustrates an alternative embodiment of a commoning member **824**. The commoning member **824** includes a body **832** that includes a plurality of the electrically conductive tabs **822** extending outwardly therefrom. The tabs **822** are pin contacts that, when the commoning member **824** is mounted on the contact module **851** (FIG. **6**), each extend within a corresponding one of the openings **820** (FIG. **6**) to directly physically engage and electrically connect each of the tabs **822** to the corresponding terminal **816**.

Referring again to FIG. **8**, the commoning member **124** may have any number of the tabs **122**, and the tabs **122** may have any suitable relative arrangement and/or pattern on the commoning member body **132**, that configures the lead frame **100** (FIGS. **3** and **4**) with the desired pattern of commoned terminals **116**. FIGS. **10** and **11** illustrate the commoning member **124** mounted on the dielectric body **102** of the contact module **51** to provide a contact module assembly **50**A having a lead frame **100**A that is configured with an exemplary embodiment of a pattern **144** of electrically commoned terminals **116***a*. Specifically, the commoning member **124** is

mounted on the side portion **108** of the dielectric body **102**. Additionally or alternatively, a commoning member **124** is mounted on the side portion **110** of the dielectric body **102**. Each of the retention members **130** is received within the corresponding opening **128** within the dielectric body **102** such that the hooks **138** are engaged with the dielectric body **102** to facilitate holding the commoning member body **132** on the dielectric body **102** of the contact module **51**. In some embodiments, in addition or alternative to the retention members **130**, the engagement between the tabs **122** and the corresponding terminals **116** facilitate holding the commoning member **124** on the dielectric body **102** of the contact module **51**.

Each of the tabs **122** is received within a corresponding opening **126***a* of the dielectric body **102** and engages the necked down portion **120** of the corresponding terminal **116***a*. Because the commoning member body **132** is fabricated at least partially from an electrically conductive material, the commoning member **124** electrically commons each of the terminals **116***a*. The commoned terminals **116***a* may each be ground terminals or the commoned terminals **116***a* may each be power terminals. A plurality of openings **126***b* within the dielectric body **102** do not receive a tab **122**, or any other portion, of the commoning member body **132** therein such that the corresponding terminals **116***b* are not electrically commoned. Each of the terminals **116***b* may be a signal terminal when the commoned terminals **116***a* are ground terminals or when the commoned terminals **116***a* are power terminals. Each of the terminals **116***b* may be a ground terminal when the commoned terminals **116***a* are power terminals, and each of the terminals **116***b* may be a power terminal when the commoned terminals **116***a* are ground terminals.

In the exemplary embodiment, the pattern **144** of the contact module assembly **50**A includes a plurality of differential pairs of signal terminals **116***b* that are separated from each adjacent pair by a terminal **116***a*. The pattern **144** begins at the outermost terminal **116** (with respect to the intersection of the mounting edge portion **106** with the rearward facing end wall **107**) with a terminal **116***a* and thereafter alternates differential pairs of signal terminals **116***b* with terminals **116***a* as the pattern **144** of terminals **116***a* and **116***b* moves toward the intersection of the mounting edge portion **106** with the end wall **107**.

Optionally, the commoning member body **132** may include one or more extensions **146** positioned to at least partially cover a corresponding opening **126***b* to thereby at least partially block exposure of the corresponding terminal **116***b* through the opening **126***b*.

FIG. **12** illustrates an exemplary embodiment of the commoning member **324**. The commoning member **324** includes a body **332** having opposite side portions **334** and **336** and a shield plate **335**, which extends coplanar with the lead frame **100** when the commoning member **324** is mounted on the contact module **51**. A pair of the retention members **330** extend outwardly on the side portion **334** for reception within the openings **128** (FIG. **3**) within the dielectric body **102** (FIG. **3**). The retention members **330** each include a pair of opposite hooks **338** that are configured to engage the dielectric body **102** adjacent the corresponding opening **128** to facilitate holding the commoning member **324** on the contact module **51** (FIG. **3**). The commoning member body **332** also includes a plurality of the electrically conductive tabs **322** extending outwardly on the side portion **334**. The commoning member **324** may have any number of the tabs **322**, and the tabs **322** may have any suitable relative arrangement and/or pattern on the commoning member body **332**, that configures the lead frame **100** with the desired pattern of commoned terminals.

FIGS. **13** and **14** illustrate the commoning member **324** mounted on the dielectric body **102** of the contact module **51** to provide a contact module assembly **50**B having a lead frame **100**B that is configured with an exemplary embodiment of a pattern **344** of commoned terminals **116***c*. Each of the retention members **330** is received within the corresponding opening **128** within the dielectric body **102** such that the hooks **338** are engaged with the dielectric body **102** to facilitate holding the commoning member body **332** on the dielectric body **102** of the contact module **51**.

Each of the tabs **322** is received within a corresponding opening **126***c* of the dielectric body **102** and engages the necked down portion **120** of the corresponding terminal **116***c*. Because the commoning member body **332** is fabricated at least partially from an electrically conductive material, the commoning member **324** electrically commons each of the terminals **116***c*. The commoned terminals **116***c* may each be ground terminals or the commoned terminals **116***c* may each be power terminals. A plurality of openings **126***d* within the dielectric body **102** do not receive a tab **322**, or any other portion, of the commoning member body **332** therein such that the corresponding terminals **116***d* are not electrically commoned. Each of the terminals **116***d* may be a signal terminal when the commoned terminals **116***c* are ground terminals or when the commoned terminals **116***c* are power terminals. Each of the terminals **116***d* may be a ground terminal when the commoned terminals **116***c* are power terminals, and each of the terminals **116***d* may be a power terminal when the commoned terminals **116***c* are ground terminals.

In the exemplary embodiment, the pattern **344** of the contact module assembly **50**B includes a plurality of differential pairs of signal terminals **116***d* that are each separated from each adjacent pair by a single terminal **116***c*. The pattern **344** begins at the innermost terminal **116** (with respect to the intersection of the mounting edge portion **106** with the rearward facing end wall **107**) with a terminal **116***c* and thereafter alternates differential pairs of signal terminals **116***d* with terminals **116***c* as the pattern **344** of terminals **116***c* and **116***d* moves away from the intersection of the mounting edge portion **106** with the end wall **107**.

FIG. **15** illustrates an exemplary embodiment of the commoning member **424**. The commoning member **424** includes a body **432** having opposite side portions **434** and **436** and a shield plate **435**, which extends coplanar with the lead frame **100** when the commoning member **424** is mounted on the contact module **51**. Mounting of the commoning member **424** on the contact module **51** is not shown herein. A pair of the retention members **430** extend outwardly on the side portion **434** for reception within the openings **128** (FIG. **3**) within the dielectric body **102** (FIG. **3**). The retention members **430** each include a pair of opposite hooks **438** that are configured to engage the dielectric body **102** adjacent the corresponding opening **128** to facilitate holding the commoning member **424** on the contact module **51** (FIG. **3**). The commoning member body **432** also includes a plurality of the electrically conductive tabs **422** extending outwardly on the side portion **434**. The commoning member **424** may have any number of the tabs **422**, and the tabs **422** may have any suitable relative arrangement and/or pattern on the commoning member body **432**, that configures the lead frame **100** with the desired pattern of commoned.

In the exemplary embodiment of FIG. **15**, each of the tabs **422** of the commoning member **424** is configured to engage and electrically connect to a corresponding terminal **116** to

electrically common all of the terminals **116** of the lead frame **100** (FIGS. **3** and **4**) of the contact module **51**. Accordingly, when the commoning member **424** is mounted on the dielectric body **102** of the contact module **51**, the commoning member **424** provides a lead frame (not shown) that is configured with a pattern (not shown) wherein all of the terminals **116** are electrically commoned. The terminals **116** that are all electrically commoned by the commoning member **424** may be configured as power terminals or ground terminals.

FIG. **16** illustrates an exemplary embodiment of the commoning member **624**. The commoning member **624** includes a body **632** having opposite side portions **634** and **636** and a shield plate **635**, which extends coplanar with the lead frame **100** when the commoning member **624** is mounted on the contact module **51**. Mounting of the commoning member **624** on the contact module **51** is not shown herein. A pair of the retention members **630** extend outwardly on the side portion **634** for reception within the openings **128** (FIG. **3**) within the dielectric body **102** (FIG. **3**). The retention members **630** each include a pair of opposite hooks **638** that are configured to engage the dielectric body **102** adjacent the corresponding opening **128** to facilitate holding the commoning member **624** on the contact module **51** (FIG. **3**). The commoning member body **632** also includes a plurality of the electrically conductive tabs **622** extending outwardly on the side portion **634**. The commoning member **624** may have any number of the tabs **622**, and the tabs **622** may have any suitable relative arrangement and/or pattern on the commoning member body **632**, that configures the lead frame **100** with the desired pattern of commoned terminals.

As described above, the embodiments of the commoning members **124** and **324** (FIGS. **8**, **10**, and **11**, and **12-14**, respectively) may include signal terminals **116***b* and **116***d*, respectively, arranged in differential pairs. However, the commoning member **624** is intended for a single-ended application. Specifically, the tabs **622** of the commoning member **624** are configured to alternatively engage and electrically connect to the terminals **116** to provide a lead frame (not shown) that is configured with a pattern (not shown) wherein each terminal **116** that is not electrically connected to the commoning member **624** is separated from adjacent terminals **116** that are not electrically connected to the commoning member **624** by a single terminal **116** that is electrically connected to, and therefore commoned by, the commoning member. The commoned terminals **116** may each be ground terminals or the commoned terminals **116** may each be power terminals. Each of the terminals **116** that are not electrically connected to the commoning member **624** may be a signal terminal when the commoned terminals **116** are ground terminals or when the commoned terminals **116** are power terminals. Each of the terminals **116** that are not electrically connected to the commoning member **624** may be ground terminals when the commoned terminals **116** are power terminals, and each of the terminals **116** that are not electrically connected to the commoning member **624** may be power terminals when the commoned terminals **116** are ground terminals.

FIG. **17** illustrates an alternative embodiment of a contact module **451** that includes an alternative embodiment of an internal lead frame **500**, shown in phantom outline, and a dielectric body **502**. FIG. **18** illustrates the lead frame **500** that is held within the contact module **451**. In the exemplary embodiment of FIGS. **17** and **18**, the contact module **451** and lead frame **500** are not configured as programmable. However, in alternative embodiments, the contact module **451** and lead frame **500** may be configured as programmable. The lead frame **500** includes a plurality of terminals **516** enclosed within the body **502**. Mating contacts **420** extend from a mating edge portion **504** of the body **502** and the lead frame **500**, and mounting contacts **458** extend from a mounting edge portion **506** of the body **502** and the lead frame **500**. A plurality of signal terminals **516***f* extend along predetermined paths to electrically connect the corresponding mating contact **420** to the corresponding mounting contact **458**. The signal terminals **516***f* include the mating and mounting contacts **420** and **458**, respectively, and an intermediate terminal portion **518**, which extends between the mating and mounting contacts **420** and **458**, respectively. A plurality of ground terminals **516***e* each include the corresponding mating contact **420**. Alternatively, the terminals **516***f* are power terminals. In another alternative embodiment, the terminals **516***e* are power terminals and the terminals **516***f* are ground terminals.

In the exemplary embodiment of FIGS. **17** and **18**, the ground terminals **516***e* each include an opening **520** that receives an electrically conductive tab **522** (FIGS. **19** and **20**) of a commoning member **524** (FIGS. **19** and **20**), as will be described in more detail below. The dielectric body **502** includes a plurality of openings **526** that each exposes the opening **520** of a corresponding one of the ground terminals **516***e*. The openings **520** and **526** may have any suitable shape that enables the openings **520** and/or **526** to function as described and/or illustrated herein. The dielectric body **502** also includes a plurality of slots **546** that each receive a portion of a corresponding ground contact **523** (FIGS. **19** and **20**) of the commoning member **524**. The slots **546** may have any suitable shape that enables the slots **546** to function as described herein.

FIG. **19** illustrates an exemplary embodiment of the commoning member **524**. The commoning member **524** includes a body **532** having opposite side portions **534** and **536**. A pair of retention members **530** extend outwardly on the side portion **534** for reception within a corresponding opening **528** (FIG. **17**) within the dielectric body **502** (FIG. **17**) to facilitate holding the commoning member **524** on the contact module **451** (FIG. **17**). The retention members **530** each include a pair of opposite hooks **538** that are configured to engage the dielectric body **502** adjacent the corresponding opening **528** to facilitate holding the commoning member **524** on the contact module **451**. The commoning member body **532** also includes a plurality of the electrically conductive tabs **522** and a plurality of the ground contacts **523** extending outwardly on the side portion **534**. In the exemplary embodiment of FIG. **17**, the ground contacts **523** are each pin contacts. However, the ground contacts **523** may each be any suitable type of electrical contact, and may each have any suitable structure and/or means, that enable the ground contacts **523** to function as described and/or illustrated herein, such as, but not limited to, IDC, pin, and/or eye of the needle contacts.

The commoning member **524** may have any number of the tabs **522** and any number of the ground contacts **523**, and the tabs **522** and ground contacts **523** may have any suitable relative arrangement and/or pattern on the commoning member body **532**. FIG. **18** illustrates the commoning member **524** mounted on the dielectric body **502** of the contact module **451** to provide a contact module assembly **50**C. Specifically, the commoning member **524** is mounted on the side portion **508** of the dielectric body **502**. Each of the retention members **530** is received within the corresponding opening **528** within the dielectric body **502** such that the hooks **538** are engaged with the dielectric body **502** to facilitate holding the commoning member body **532** on the dielectric body **502** of the contact module **451**.

Each of the tabs **522** is received within a corresponding opening **526** of the dielectric body **502**. Each of the tabs **522**

is also received within the opening **520** of a corresponding ground terminal **516***e* such that the tab **522** is directly physically engaged and electrically connected to the corresponding ground terminal **516***e*. Because the commoning member body **532** is fabricated at least partially from an electrically conductive material, the commoning member **524** forms a common ground of each of the ground terminals **516***e* that are electrically connected thereto.

In the exemplary embodiment, the pattern **544** of the contact module assembly **50**C includes a plurality of differential pairs of signal terminals **516***f* that are separated from each adjacent pair by a single ground terminal **516***e*. The pattern **544** begins at the outermost terminal **516** (with respect to the intersection of the mounting edge portion **506** with the rearward facing end wall **507** of the contact module **451**) with a ground terminals **516***e* and thereafter alternates differential pairs of signal terminals **516***f* with ground terminals **516***e* as the pattern **544** of signal and ground terminals **516***f* and **516***e*, respectively, moves toward the intersection of the mounting edge portion **506** with the end wall **507**. The ground contacts **523** are each received within a corresponding slot **546** to form ground contacts on the mounting face **56** (FIG. **1**) of the connector **10** (FIG. **1**).

The patterns of signal, ground, and/or power terminals described and/or illustrated herein (e.g., the patterns **144**, **344**, and **544** shown in FIGS. **11**, **14**, and **20**, respectively, as well as the patterns formed by the commoning members **424** and **624** that are shown in FIGS. **15** and **16**) are meant as exemplary only. The lead frame embodiments described and/or illustrated herein may be programmable into any other suitable patterns of signal, ground, and/or power terminals that enables the lead frame to function as described herein.

The embodiments described herein provide an electrical connector having a programmable lead frame. The embodiments described herein provide an electrical connector that may cost less and/or be more easily manufactured as compared to at least some known electrical connectors.

Exemplary embodiments are described and/or illustrated herein in detail. The embodiments are not limited to the specific embodiments described herein, but rather, components and/or steps of each embodiment may be utilized independently and separately from other components and/or steps described herein. Each component, and/or each step of one embodiment, can also be used in combination with other components and/or steps of other embodiments. When introducing elements/components/etc. described and/or illustrated herein, the articles "a", "an", "the", "said", and "at least one" are intended to mean that there are one or more of the element(s)/component(s)/etc. The terms "comprising", "including" and "having" are intended to be inclusive and mean that there may be additional element(s)/component(s)/etc. other than the listed element(s)/component(s)/etc. Moreover, the terms "first," "second," and "third," etc. in the claims are used merely as labels, and are not intended to impose numerical requirements on their objects. Further, the limitations of the following claims are not written in means—plus-function format and are not intended to be interpreted based on 35 U.S.C. § 112, sixth paragraph, unless and until such claim limitations expressly use the phrase "means for" followed by a statement of function void of further structure.

While the invention has been described in terms of various specific embodiments, those skilled in the art will recognize that the invention can be practiced with modification within the spirit and scope of the claims.

What is claimed is:

1. A contact module assembly for an electrical connector, said contact module assembly comprising:

a lead frame having a plurality of terminals at least partially overmolded in a dielectric material; and

a commoning member comprising an electrically conductive material disposed along a side of the dielectric material, the commoning member having a plurality of tabs that are electrically connected to selected ones of the terminals, thereby electrically commoning the selected ones of the terminals, wherein the commoning member can be configured with different patterns of the tabs to selectively configure the lead frame with different patterns of commoned terminals, and wherein each of the tabs of the commoning member comprises one of an insulation displacement contact (IDC), a pin contact, and an eye of the needle contact.

2. The contact module assembly of claim **1**, wherein at least one of the selected ones of the terminals is electrically connected to more than one of the tabs.

3. The contact module assembly of claim **1**, wherein all of the terminals of the lead frame are electrically commoned by the commoning member.

4. The contact module assembly of claim **1**, wherein the tabs physically secure the commoning member to the lead frame.

5. The contact module assembly of claim **1**, wherein all of the terminals are arranged in a plane and the commoning member includes a shield plate that extends parallel to the plane.

6. The contact module assembly of claim **1**, wherein the tabs of the commoning member engage the selected ones of the terminals through corresponding openings within the dielectric material.

7. The contact module assembly of claim **1**, wherein the tabs of the commoning member engage necked-down portions of the selected ones of the terminals.

8. The contact module assembly of claim **1**, wherein the tabs of the commoning member are received within openings within the selected ones of the terminals.

9. The contact module assembly of claim **1**, wherein each of the terminals extends between a mating edge portion and a mounting edge portion of the lead frame and at least one of the terminals includes an intermediate portion that electrically connects a corresponding first electrical contact of the terminal on the mating edge portion with a corresponding second electrical contact of the terminal on the mounting edge portion.

10. The contact module assembly of claim **1**, wherein each of the terminals includes a first electrical contact on a mating edge portion of the lead frame and a second electrical contact on a mounting edge portion of the lead frame, wherein at least one of the selected ones of the terminals does not include an intermediate portion that connects the first electrical contact with the second electrical contact.

11. An electrical connector comprising:

a housing; and

a plurality of contact module assemblies held by the housing, each of the contact module assemblies comprising:

a lead frame having a plurality of terminals at least partially enclosed in a dielectric material; and

a commoning member comprising an electrically conductive material disposed along a side of the dielectric material, the commoning member having a plurality of tabs that are electrically connected to selected ones of the terminals, thereby electrically commoning the selected ones of the terminals;

wherein at least two of the contact module assemblies are configured with respective different patterns of commoned terminals.

12. The electrical connector of claim **11**, wherein at least one of the contact module assemblies includes a plurality of differential pairs of signal terminals that are separated from each other by respective commoned ground terminals.

13. The electrical connector of claim **11**, wherein all of the terminals of least one of the contact module assemblies are electrically commoned by its said commoning member.

14. The electrical connector of claim **11**, wherein the terminals of each said contact module assembly are arranged in a plane and the commoning member of each said contact module assembly includes a shield plate that extends parallel to the plane.

15. The electrical connector of claim **11**, wherein the tabs physically secure each said commoning member to its respective said lead frame.

16. The electrical connector of claim **11**, wherein the tabs of each said commoning member engage the selected ones of the terminals through corresponding openings within the dielectric material.

17. The electrical connector of claim **11**, wherein each of the tabs comprises one of an insulation displacement contact (IDC), a pin contact, and an eye of the needle contact.

18. The electrical connector of claim **11**, wherein each of the terminals of the lead frame of one of the contact module assemblies includes a first electrical contact on a mating edge portion of the lead frame and a second electrical contact on a mounting edge portion of the lead frame, and wherein at least one of the selected ones of the terminals includes an intermediate portion that connect its corresponding said first electrical contact with its corresponding said second electrical contact.

19. The electrical connector of claim **11**, wherein each of the terminals of the lead frame of one of the contact module assemblies includes a first electrical contact on a mating edge portion of the lead frame and a second electrical contact on a mounting edge portion of the lead frame, and wherein at least one of the selected ones of the terminals does not include an intermediate portion that connects its corresponding said first electrical contact with its corresponding said second electrical contact.

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